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ABSTRACT

The BrainLink project offers educational materials focusing on current neuroscience issues with the goal of promoting a deeper understanding of how the nervous system works and why the brain makes each individual special while conveying the excitement of "doing science" among upper elementary and middle school students. Project materials engage students and their families in neuroscience issues as they learn fundamental physical and neuroscience concepts and acquire problem-solving and decision making skills. Each BrainLink unit targets a major neuroscience topic and consists of a colorful science Adventures storybook, a comprehensive Teacher's Guide to hands-on activities in science and mathematics, a Reading Link language arts supplement, and a fun and informative Explorations mini-magazine for students to use with their families at home or in the classroom. This issue provides a novel approach to learning more about the make-up of the brain and the basics of intelligence. (ASK)

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Skullduggery: A Case of Cranium Confusion.

BrainLink: Brain Comparisons.

By Grace Boyle
Illustrated by T. Lewis
Revised by Barbara Tharp and Judith Dresden
Science notations by Nancy Moreno

SE 064 336

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BrainLink
BRAIN COMPARISONS

SKULLDUGGERY

A CASE OF THE NEURO EXPLORERS CRANIUM CONFUSION

SE064336

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Written by Grace Boyle
Illustrated by T Lewis

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The **BrainLink®** series for health and science education provides:

- Adventures in learning: Story Books
- Exciting hands-on: Activities Guide for Teachers
- Engaging health/science mini-magazine: Explorations for Children and Adults

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Skullduggery
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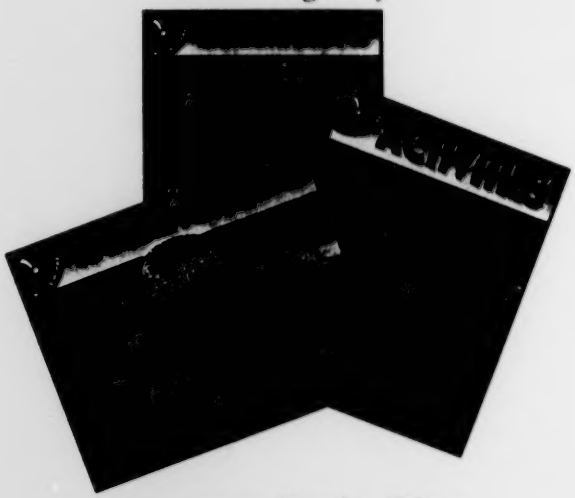

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BrainLink® Adventures

SKULLDUGGERY

The NeuroExplorers™ in A Case of Cranium Confusion

By
Grace Boyle
Illustrated By
T Lewis
Revised by Judith Dresden, M.S. and Barbara Tharp, M.S.
Science notations by Nancy Moreno, Ph.D.
Baylor College of Medicine

WOW Publications
Houston

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For information, call 1-800-969-4996

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The NeuroExplorers

The Beginning

All Josh Kavil saw was the stop sign. The next thing he remembered was waking up in the hospital. He had been riding his bicycle without a helmet and was struck by a car. His skull was fractured, and his brain was badly damaged.

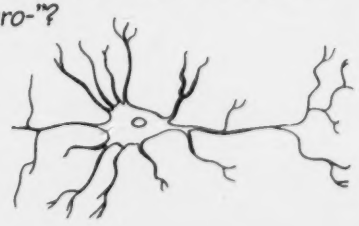
Some good came of Josh's unfortunate accident. For one thing, he learned never to ride without a helmet. Second, his misfortune was the beginning of the NeuroExplorers.

When Josh's friends came to visit him at Worthington Regional Hospital, some of them became fascinated with the field of neuroscience. On their visits, they met a neurosurgeon, a neurosurgical nurse, a neurologist and a neuroradiologist. These were medical specialists helping patients who had problems involving the brain or other parts of the nervous system.

It was Kyle Christian's idea to form the club. The members all wanted to know more about the nervous system. They also liked to solve puzzles and riddles and had an interest in investigating some of the mysteries of science.

Since they formed the club, the NeuroExplorers have volunteered at a center for the rehabilitation of brain injury patients, held a Neuro-Science Fair and spent a day in the hospital on rounds with a neurologist. They have learned a lot about how the brain and nervous system work, and they always are looking for exciting things to do with neuroscience.

Neuroscientists study the brain and the rest of the nervous system. The basic building block of the nervous system is the nerve cell, or neuron. The word "neuron" comes from the Greek word for "nerve." How many words can you find that start with "neuro-"?



The Club Members

Kyle Christian

Kyle's father is an archaeologist at Dargate University and often is away on digs. Last year, he took Kyle with him on a short dig in Belize. Kelly, Kyle's sister, sometimes does things with the NeuroExplorers, although some of the members feel that she is a little young for the club. Kyle likes to read science fiction books and play computer games. His hobby is memorizing fascinating trivia.

The Brain

When Antonio Velasquez-Ruíz, alias The Brain, was a toddler, he was very quiet and never tried to talk. One day he suddenly began speaking in complete sentences. Since then, he has been known as the smartest boy in town. The trouble is, only his best friend can understand The Brain's big words and long sentences. The Brain reads a lot, but his most-used books are a very fat dictionary, a set of encyclopedias, and Gray's Anatomy.

Max Miller

Max has been friends with The Brain since they were babies, and that's why he understands him so well. They spend most of their time together. While The Brain reads, Max often works on models of boats and planes or builds things with wood. Max became interested in neurology when his grandfather had trouble with his memory and was diagnosed with Alzheimer's disease.

Lakeisha Crawford

Lakeisha wants to be a chess grandmaster, so she carries a pocket chess game around with her. She often thinks about things in terms of chess problems, and she has developed a good memory. She also likes to play other games and sports. Karate lessons are her latest passion. Lakeisha has a little sister who has epilepsy.

Isley I and Isley II

Identical twins, Isley I and II (even their parents don't call them by their actual first names) are always kidding each other. They both love sports and play soccer, baseball and basketball. Isley I collects baseball cards and has a 1954 Mickey Mantle in good condition. Isley II holds the record for consecutive basketball free throws in his school. Their father, a bird-watcher, got them interested in science by reading to them from the notes of Charles Darwin.

B.J. Armstrong

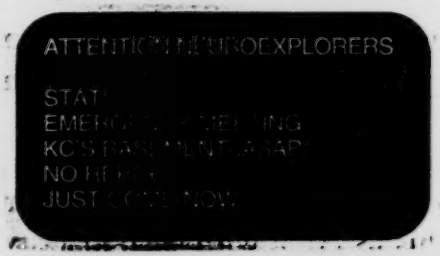
B.J. spends a lot of time with her drums. In fact, she carries her drumsticks with her and uses them on any hard surface she can find! She wants to play in a band, but she also wants to be a physician. B.J. has two older brothers who sometimes act as advisors to the NeuroExplorers. One brother is a neurologist at a medical school. Her brothers never liked to use her formal name, Beverly Jane, so they've always called her B.J., and so do her friends.

SKULLDUGGERY

Calling All NeuroExplorers

Grinning a cracked-tooth smile, a model human skull peered down from the shelf above Kyle Christian's head. The skull's neighbor was a gray plastic brain, and both lay below a giant wall poster that said, THINK! YOUR MIND DEPENDS ON IT!

Kyle didn't notice the skull's grin or the model brain's icy silence. He was deep in thought, his fingers flying across the computer keyboard, typing out this urgent message:



Click! He sent his message scurrying across the Internet to the homes of the NeuroExplorers. He needed the club here. On the double!

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In minutes, the NeuroExplorers arrived. Kyle looked around his basement. Lakeisha, B.J., Isley I and II, Max and The Brain were all there. The Brain, of course, was the first to speak.

"Kyle, I'm sure I speak for all of the NeuroExplorers. We admire your leadership qualities, forthrightness and general acumen. But was it really necessary to expedite this meeting with such alacrity?"

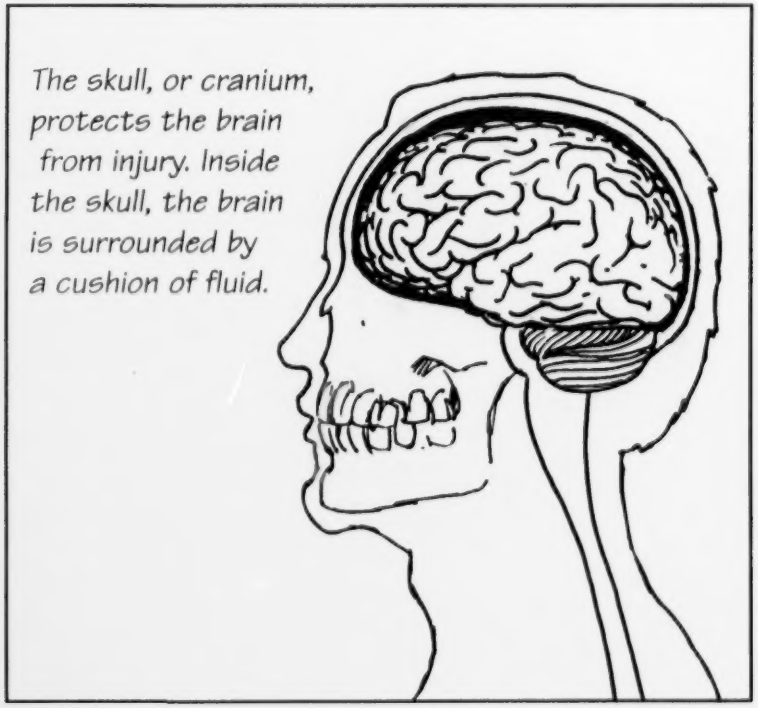
Kyle looked at Max. He was The Brain's translator. "He wants to know why you made us run over here like there was a major catastrophe or something."

Kyle smiled. "Thanks Max. There *is* an emergency, Brain. I think we need to take action, fast. It's time for a skull session."

Everyone started talking at once. The Isley twins, I and II, seemed annoyed. "Does this mean we'll miss the basketball game tonight?" Isley I asked. "I hate to miss championship games," Isley II finished.

"This isn't just another case like helping Laura Bolter look for her missing science project, is it?" asked Lakeisha.

"Hold on, hold on everyone," Kyle said, waving his hands. "We have a real puzzle to solve. Someone truly needs our help. This is an official NeuroExplorers double-barrel, full scale alert!" The room fell silent.



The skull, or cranium, protects the brain from injury. Inside the skull, the brain is surrounded by a cushion of fluid.

"Who?" asked Isley I. "And where?" asked Isley II.

"Professor Paul Ottzinger. The Skull Caves at Calicoon," Kyle replied.

The room was quiet. The NeuroExplorers sat in stunned silence. The grinning skull seemed to be laughing to itself.

"Extraordinary!" whispered The Brain.

Who Took The Mishigara Man?

Kyle scanned the blank faces of the NeuroExplorers. They all knew about Ottzinger. He was a professor at nearby Dargate University, and his specialty was skulls. He was a well-known expert, and once he had brought his skull exhibit to their school. Recently, the most famous and valuable skull of all, the prehistoric Mishigara Man's, had disappeared from Professor Ottzinger's laboratory. The papers were full of stories about who might have taken the skull, and why. People even suspected Ottzinger, himself.

But Kyle knew that it wasn't so much the thought of Ottzinger that had frightened the group into silence. It was the mention of The Skull Caves at Calicoon—dark, frightening caves that were shaped like a human skull.

Kyle broke the bone-cold silence. "This is just the opportunity we've been waiting for, believe me," he said.

"Some explanation is mandatory," The Brain said, stonefaced.

"Explain, please," Max interpreted without prompting.

"Well," Kyle started slowly, "I was going through my e-mail on the computer, and I found a letter in my mailbox."

Isley I looked up. "Don't tell me. The letter was written by..."

"Professor Ottzinger," Isley II finished.

Leaning off the edge of her seat, nervously tapping her drumsticks, B.J. looked at Kyle. "Professor Ottzinger?" she said. "What could he possibly want with us?"

"Why don't I let him tell you?" Kyle said.

Ottzinger's Plan

Suddenly, hovering far above the heads of the NeuroExplorers, a tall figure appeared in the doorway. It was Professor Ottzinger. "You can give me my last chance," he said.

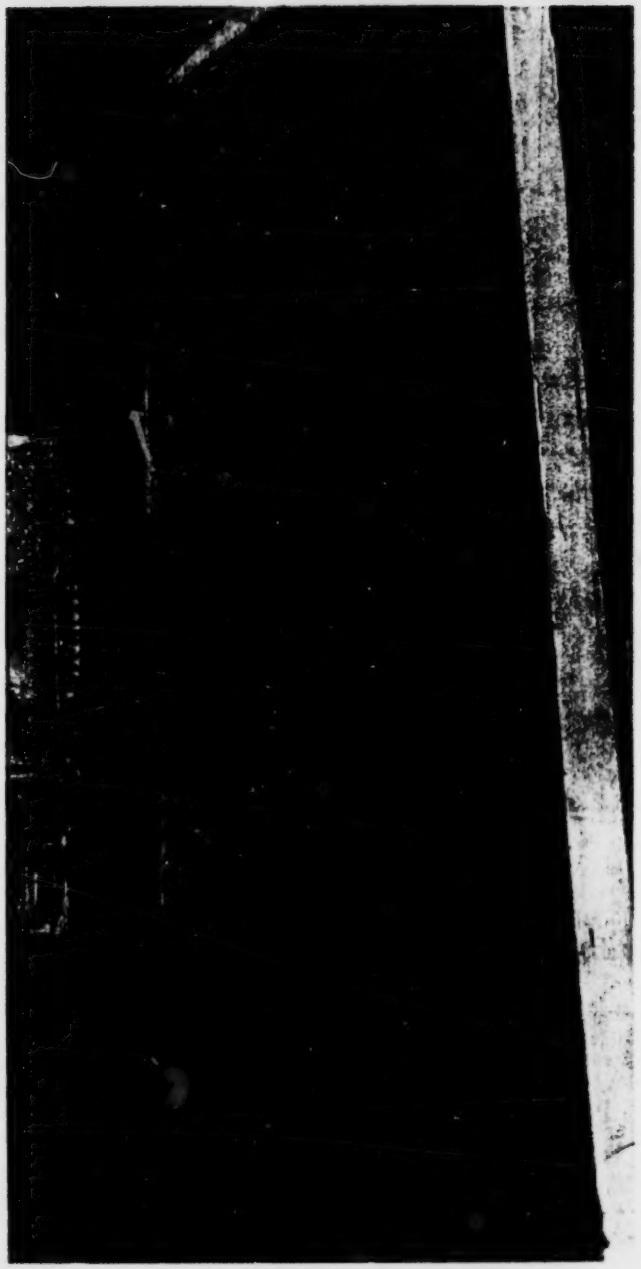
A look of concern came over Max's face. The professor's voice seemed desperate.

"I need the NeuroExplorers to help me find the Mishigara Man and to clear my name," Professor Ottzinger continued. "I think I know who stole the skull, and I believe I know where it is now."

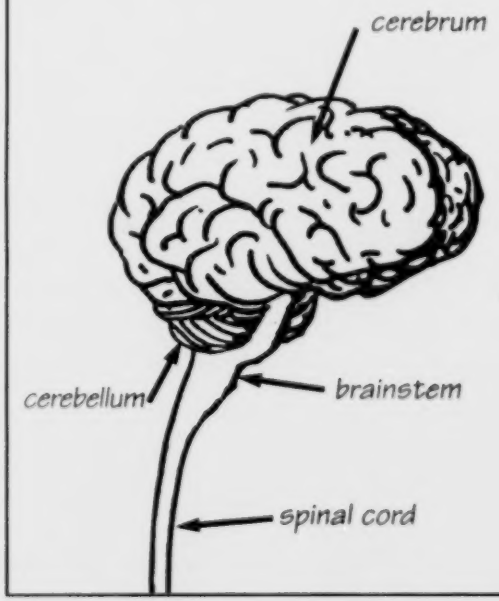
"Don't tell me...." said Isley I.

"The Skull Caves at Calicoon," finished Isley II.

The Caves! Little children were lost there forever! Mountain lions and snakes guarded the entrance. These were the stories the NeuroExplorers had heard about the Caves at Calicoon.



The cerebrum is the largest part of the brain. It controls learning, memory and thinking. It also is the center of our emotions and senses. The cerebrum even is in charge of directing muscle movements. The cerebellum stores the programs that help muscles work together smoothly. The brainstem controls automatic body functions like the heartbeat, digestion, breathing, swallowing, coughing and sneezing.



With a trembling voice, Lakeisha spoke up first. "I thought *you* took the Mishigara Man," she said to the professor.

Lakeisha's bravery inspired Max to say, "And even if you didn't, why would anyone take it to the Caves?"

Ottzinger looked around the room at each NeuroExplorer. "I assure you, I did not steal the Mishigara Man. As for Calicoon, what better place to hide the stolen skull than a cave where everyone is afraid to go? After the whole affair dies down, the thief just gets the skull from the cave and is off with it."

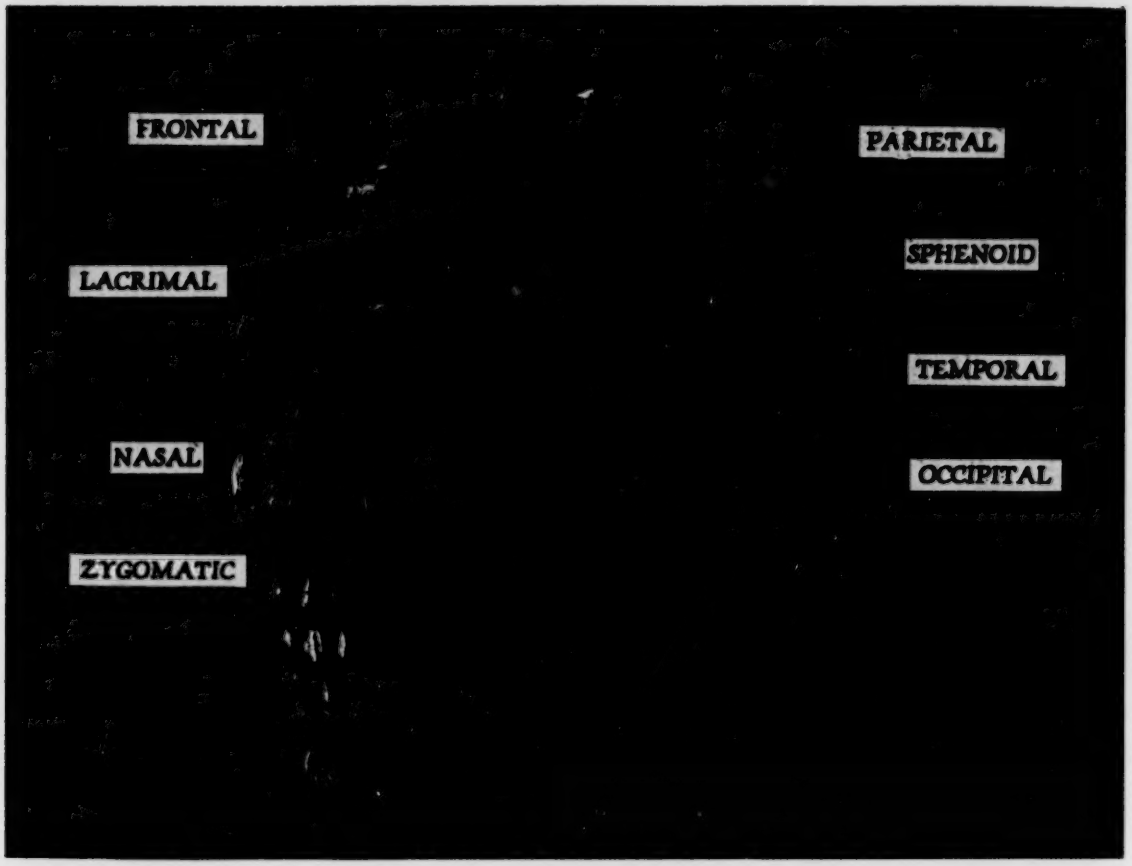
"Exceptional plan!" The Brain said approvingly. "But of what service are we?"

"How can we help?" Max echoed.

"I need the NeuroExplorers to come with me to the Caves to look for the skull. The Caves are very old. There may be many confusing bones. I need a group that is brave, adventurous and intelligent, with special knowledge of skulls and the brain. And you can fit into small spaces better than I! What do you think?"

"Sounds like us," said Isley I.

"Speak for yourself," said Isley II.



Preparing for the Worst

Ottzinger disappeared as mysteriously as he had come, leaving the NeuroExplorers in a haze of wonder.

Kyle acted quickly to snap them out of it. Marching to the front of the room, he pulled down a chart. "We need to go over a few facts," he said. "There could be lots of skulls at the Caves. We have to be able to tell them apart. Let's start with some basics. Why is the cranium hard?"

"Isley I should be able to answer that. He's a hard-head!" Isley II said.

Isley I picked up a beach ball and threw it at Isley II. "The cranium has to be hard to protect the brain, which is soft," he said.

"Good," Kyle said. "Let's keep rolling." Kyle looked over at B.J. who was pretending to play the drums on the sofa. "B.J.?" Kyle said.

"Yes?" B.J. answered.

"Can you stop playing drums for a second and describe the cranial bone to me?" Kyle asked, pointing to the illustration on the chart.

"Playing drums helps me remember," B.J. said, smiling. "Two layers of hard bone," B.J. said, striking her sticks on two invisible drums. "There's a softer layer of bone marrow between them," she said, finishing with a smash on her imaginary cymbals.

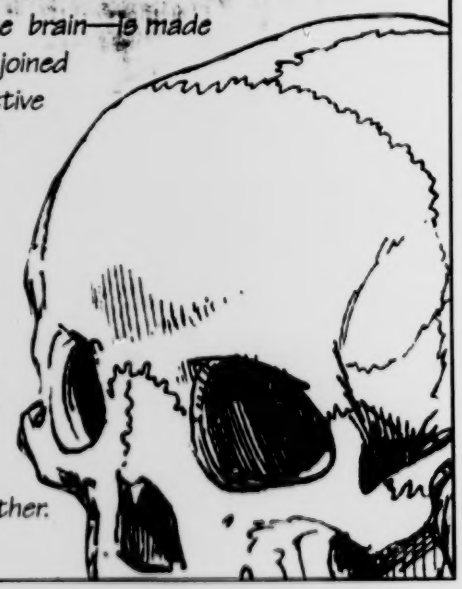
"Laudatory response!" said The Brain.

"Good answer!" Max interpreted.

"O.K.," Kyle called out. "Let's try this one. Who can name the major bones of the cranium?"

Lakeisha was quick to answer. "Temporal, frontal, parietal, occipital, and sphenoid," she said rapidly.

The human skull is made up of 22 different bones. The cranium—the top part of the skull that surrounds most of the brain—is made up of eight thin bones joined to form a hard protective "helmet." The bones of the skull meet at irregular joints called sutures. The jagged-looking edges of the sutures actually provide extra strength to the skull, because the different pieces are locked or "zipped" securely together.



"You forgot nasal, zygomatic and lacrimal," added B.J., with a drumroll.

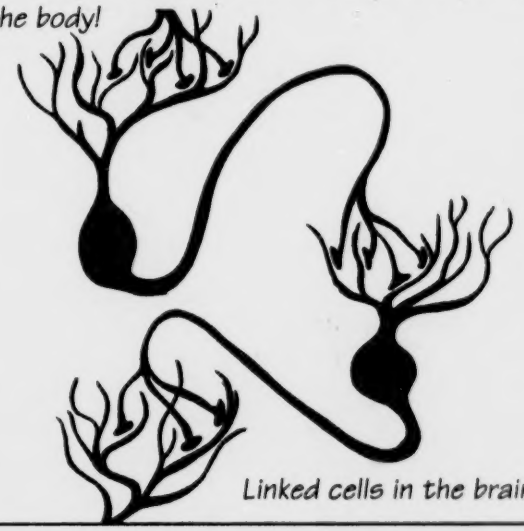
Lakeisha shot B.J. a quick look. "He said *major* bones," she replied.

"Let's not quibble," said The Brain.

"Cool it," added Max.

The NeuroExplorers began to get excited. They knew a lot about skulls and the brain. They *would* help find the Mishigara Man. Somehow they believed in Professor Ottzinger, and they could help clear his name. Besides, it sounded like a great adventure. They would go to—the Skull Caves at Calicoon!

The brain, which is shielded by the skull, is the command center of the body. It is made up of billions of cells. It controls all the movements of the body and processes all the information taken in by the senses. The amazing brain is the most complex organ of the body!



Linked cells in the brain

The Caves at Calicoon

Agreeing to meet at nine on Saturday morning, the NeuroExplorers went home to explain the plan to their families, collect their gear and get a good rest before starting out on their adventure.

On Saturday, the seven fearless explorers hopped on their bikes, helmets secured and gear stowed in backpacks. They rode the five miles to a place somewhat to the north of Calicoon and then onto a dirt road to the Skull Caves. Professor Ottzinger was there to meet them. Leaving their bikes outside, they stepped cautiously into a large, dark hole.

The coolness of the rock walls wrapped around the NeuroExplorers like a wet blanket. Their flashlights poked holes through the inky blackness. Kyle knew they were deep into an adventure as he led the club members, behind Professor Ottzinger, into the Skull Caves at Calicoon.

Suddenly Ottzinger stopped, turned and said to the NeuroExplorers, "There's one thing Kyle and I haven't told you."

A shiver passed electrically through the whole group.

"Show them the map, Kyle," said Professor Ottzinger.

"I have a map of the Caves," Kyle explained, unfurling a rolled paper. He shined his flashlight on the opened map as Lakeisha and B.J. held it down at the edges. "One of the reasons the professor needed us for this job," Kyle said, "is because the Caves are laid out like..."

"The sinuses in a cranium," Ottzinger finished.

"The sinuses?" asked Isley II.

"Don't be slow, Isley II," said Isley I. "You know what the sinuses are. Everyone has them. They're the large air spaces in the cranium."

"Yes, of course," Lakeisha said quickly, "frontal, sphenoid, maxillary and..."

"Ethmoid," finished Max, "the four main sinuses."

The Brain spoke up. "Not quite," he said. "The sinuses are paired, bilateral and roughly symmetrical, so technically there are eight sinuses, although the sphenoids are midline and appear as a single entity."

Professor Ottzinger squinted hard as he stared through the darkness at The Brain. "What did you say?" he asked.

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"The Brain says that there are two of each sinus, one on either side of the cranium. The sphenoid sinuses are right in the middle of the cranium and look like just one sinus," Max explained.

"Right you are," Ottzinger said slowly. "Good point."

"It's much easier if you just look at this drawing," Kyle said, pointing to his papers. "Here is a picture of the sinuses, just as we described them. And here is the map of the Caves. Isn't it amazing? They're almost alike! Anyway, we're going to split up," Kyle went on, handing out small versions of the map to each NeuroExplorer. "Isley I and II will start with Professor Ottzinger in the frontal sinus. B.J. and Lakeisha begin in the sphenoid sinus, and Max, The Brain and I start in the maxillary sinuses."

The sinuses are connected to the cavities of the nose by tiny tunnels about the width of a pencil lead. The sinuses are lined by thin layers of cells that filter and moisten the air we breathe. Sinuses easily can become blocked after a bad cold or bout with allergies. This can cause headaches or stuffiness.

"What about the ethmoid?" B.J. asked.

"We all meet there," Kyle said.

"Yes, and bring anything you find that you think could be the missing skull of the Mishigara Man," Professor Ottzinger added.

"Doesn't sound too difficult," Lakeisha said.

"Unless someone is guarding the Mishigara Man and doesn't want us to take it away," B.J. said. "Then it could be *highly* difficult!"

The Brain calmly folded his map, tucked it into his pocket and smoothed his hair with the palm of his hand. "Even a novice prognosticator would predict a daunting intellectual and physical task."

Everyone looked at Max. He shrugged his shoulders. "I guess he means we have our work cut out for us!" he said.

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Problems in the Frontal Sinus

Climbing slowly, Isley I and II led Professor Ottzinger up an old path to the highest cave—the frontal sinus. The twins pulled themselves over the final stone wall and stood facing a deep, dark open chamber. "This must be it," said Isley I.

"The frontal sinus," finished Isley II.

Suddenly, Isley I was hit from behind. Sprawling forward, he lurched, grabbing Isley II by the arm and spinning him around. An instant later, the

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air was filled with wild sounds of something beating and fluttering. Wings seemed to sprout from the air, surrounding the two NeuroExplorers.

"Stay down!" yelled Isley II, throwing up his arms to cover his head.

"What is it?" cried Isley I.

"Bats!" Isley II answered. "Must be a million billion bats!"

Isley I and II covered each other beneath the storm of flying mammals. It seemed like an hour before the cave was quiet again. Isley I lifted his head, scraping sand off his cheek. "I think they've gone," he whispered.

Isley II refused to lift his head. "I hate bats," he mumbled to the ground.

"Look, Isley II, look at this!" his brother suddenly shouted.

Peeking over his arm, Isley II squinted, adjusting to the dark cavern. Isley I was holding a small skull! "Could this be the Mishigara Man?" he said.

Isley II shook his head. "I don't know," he said, "it looks kind of small. Let's ask Professor Ottzinger. Hey, Professor..."

Isley II looked at Isley I. "Ottzinger's gone!" they both yelled.

"Don't yell!" they both said together again.

Too late. In another second the cave was again alive in a blizzard of bats. Scrambling to their feet, the twins took off, hundreds of bats shooing them from the frontal sinus.

Clutching the tiny cranium, running as hard as he could, Isley I couldn't help thinking, *What happened to Ottzinger?*

Snakes in the Sphenoid

Lakeisha loved chess, karate and being a NeuroExplorer. But she wasn't crazy about heights, and she hated snakes. Yet there she was, sitting high atop a boulder in the middle of a dark cave, surrounded by swampy water filled with snakes. She looked at B.J. "Walking across that rotten old plank was not a very good idea, B.J.," she said.

"How could we know it would collapse? At least we landed on this huge rock," B.J. replied.

Lakeisha listened to the hissing from the murky water below. She thought she could see long, thin forms slithering through the slime. "Snakes!" she moaned.

"Don't think about the snakes," B.J. said bravely, tapping her fingers on her flashlight.

"Hey! Think about that skull!" Lakeisha blurted out. She had spotted a cranium stuck in the side of the wall across the cavern.

"You're right!" B.J. said, inching forward to get a better look. "That could be the Mishigara Man." B.J. leaned too far. In a second she was sliding across the rock face, down the edge of the boulder. Lakeisha reached out. Their hands clasped for a second, but B.J. slipped over the edge and down, down into the darkness.

Lakeisha heard a splash. "B.J.!" she yelled. "The snakes! Swim! Get out! B.J.!" In her panic, Lakeisha lost her balance, and in another instant she, too, was sliding down the boulder. The cold, murky water greeted her.

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Lakeisha struggled for a second until she realized that she was fighting B.J. Their arms were wrapped around each other.

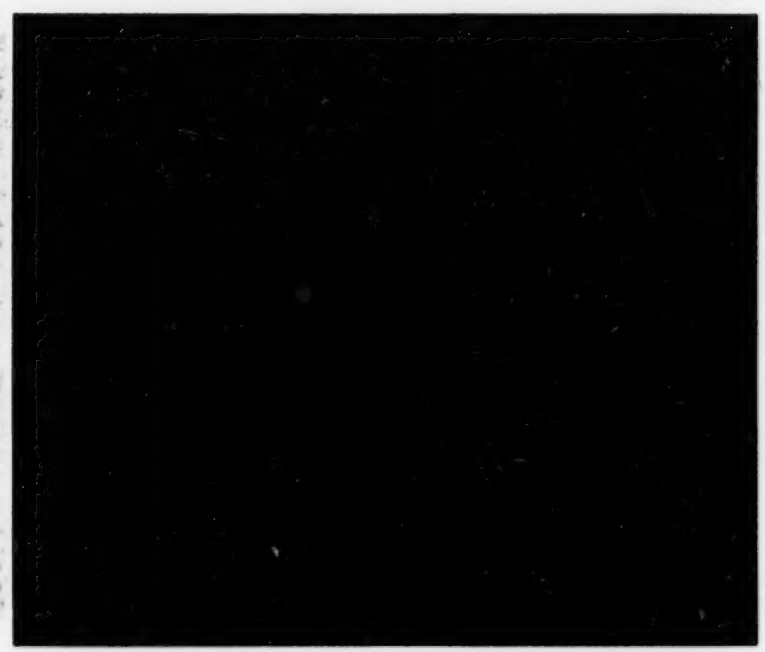
"It's okay, Lakeisha," said B.J., slowly relaxing her grip.

"But the snakes!" Lakeisha said, still horrified.

"They're vines," B.J. said, almost laughing. "Not snakes. Just big vines."

"But that hissing?" Lakeisha insisted.

The cerebrum is the thinking part of the brain. The cerebrum in most mammals looks wrinkled. The folds and wrinkles on the surface of the cerebrum are called gyri. This folding allows more tissue that is important for thinking to fit into the cranium.



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"Water coming out of the rocks over there," B.J. answered. "Come on, let's swim over to that skull. It could be the one we want."

In a few minutes, B.J. and Lakeisha had the skull and pulled themselves out of the water. "That doesn't look like a human cranium," Lakeisha said. "Too small. Not enough impressions inside."

"Impressions?" B.J. asked.

"From wrinkles in the cerebrum. Advanced brains, like humans', have more of the wrinkled thinking part. You know that," Lakeisha said.

B.J. tapped her right foot as if she were trying to pump up her memory. "That's right," she said, finally. "And to fit all that cerebral tissue inside the cranium, the brain surface is folded over many times. Those wrinkles are called gyri, and they make marks on the inside of the cranium. So the more marks, the more advanced the brain."

"Right," Lakeisha said quickly, turning the skull over in her hands. "This one can't be human."

"Should we look around some more?" B.J. asked. "Uh-oh!" she said, pointing to something moving on the cave floor.

Lakeisha looked down. A snake was slicing through the gravel toward them. Its tongue flickered quietly.

Without a word, the two girls turned at the same time and carefully walked away. "I think we'd better just head for the ethmoid and see what the others have found, don't you?" said Lakeisha when they had put some distance between themselves and the snake.

The Brain Runs into a Wall

"What did The Brain say?" Kyle asked Max.

"He thinks we're lost," Max said with concern.

Kyle studied the map for the tenth time. "I don't know how we could be lost. I followed the map exactly. We should be standing in the maxillary sinus cave right now."

Max paced back and forth. Kyle studied the map. The Brain was staring at a wall.

"Brain," Kyle said impatiently, "you *could* help us over here, instead of staring at the wall."

"Prefabricated, I would guess," The Brain said without turning. "Hardly a Pliocene artifact."

Even Max was confused. "Brain, what are you talking about? We need your help to find the maxillary sinus!"

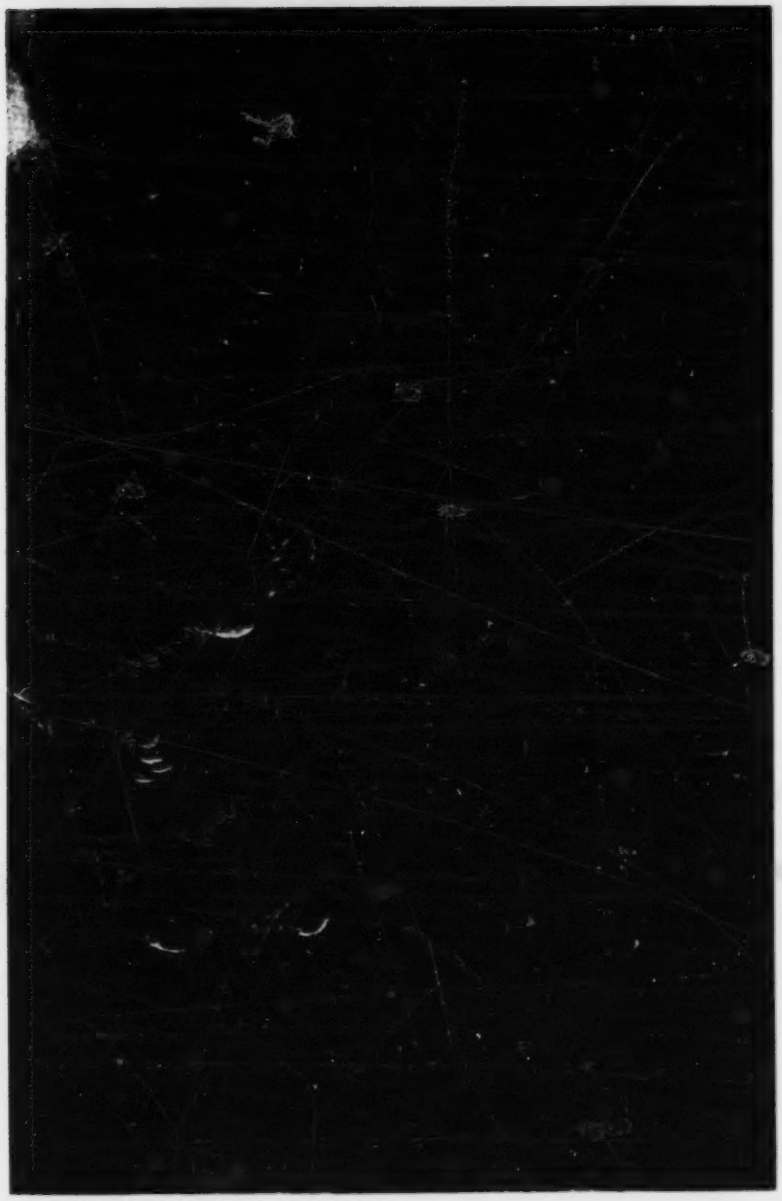
"I'm trying to do just that," the Brain answered, scratching the wall. "This cave wall is ersatz, spurious, unauthentic."

Max grabbed his friend by the shoulders and shook him. "What do you mean?" he said. "Can't you speak plain English for a change?"

The Brain faced his friends and said, "This wall is not rock. It's not real. A fake plaster copy. Phoney baloney! How's that?... It may be hiding the maxillary sinus cave."

Max almost hugged him. "I'm sorry, Brain. How could I have doubted you?"

Running across the floor of the cave, Kyle kicked the fake wall with his foot, opening a large hole in the plaster.

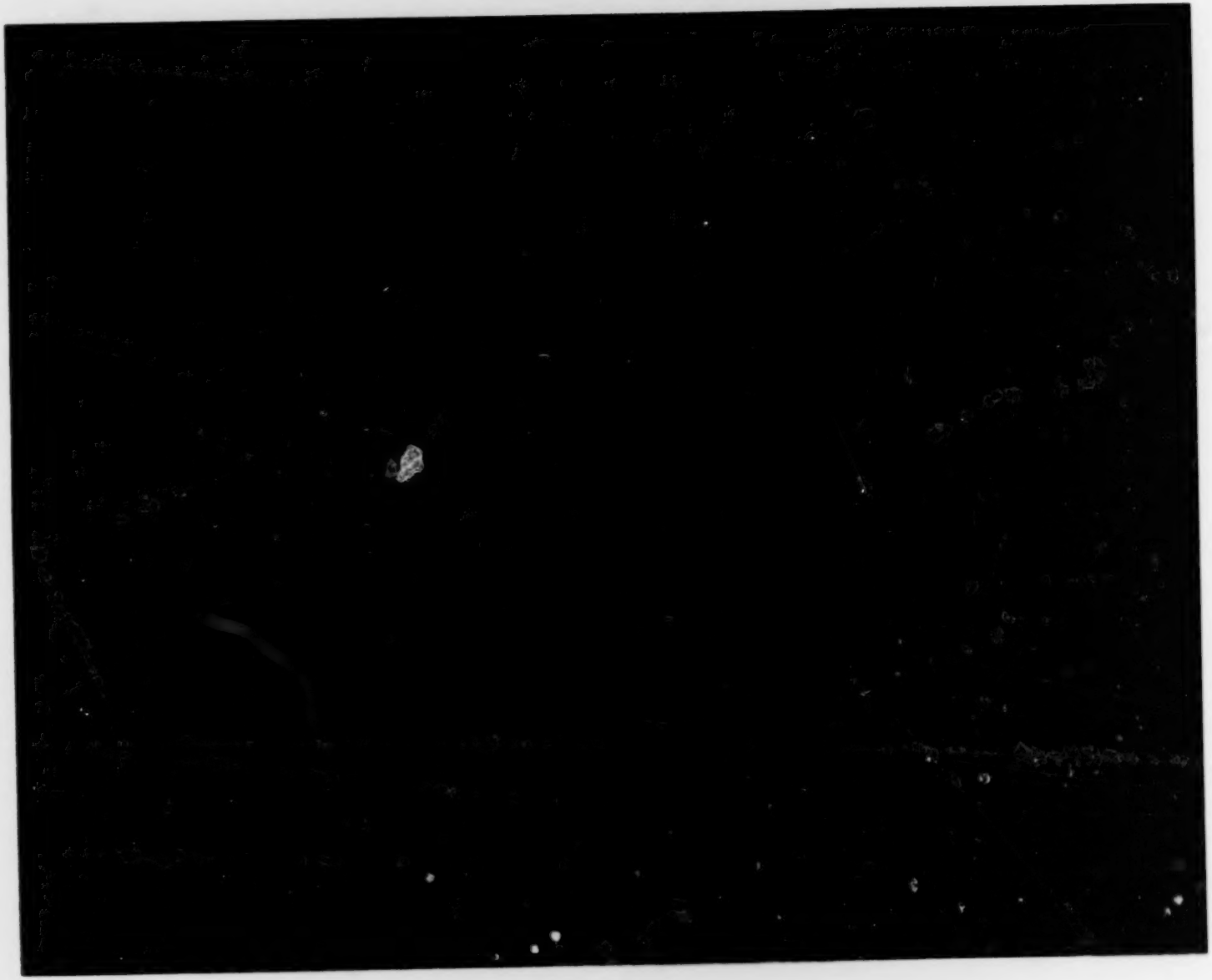


"That's it!" Kyle said, leaning through the opening. "This *is* the maxillary sinus. Let's go!" The NeuroExplorers stepped through the opening into a great cavern.

Sorting Skulls

After dashing out of the frontal sinus cave, Isley I and II had tumbled down a long rocky slope, jumped a small stream and ducked through two long tunnels. Finally, they dragged themselves into the ethmoid area—and there was Ottzinger, crouching over a pile of bones with Lakeisha and B.J.

Isley I looked at Isley II before he spoke. "Professor Ottzinger?" he said.



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The darkly clad man twisted his neck to look at Isley I. "Yes? Oh, I'm glad you finally made it," he replied.

"What are *you* doing here?" asked Isley I.

"Where did you go? We thought you were with us," finished Isley II.

Ottzinger shrugged and said, "Oh, uh, I...I found a short cut, and...I thought you were right behind. Where have you been?"

Intelligence in animals is related to the amount of wrinkles on the cerebrum. It also is related to how large their brains are, compared to the rest of their bodies. Some large animals actually have very small brains compared to the overall size of their bodies. Others, such as chimpanzees or humans, have relatively large brains compared to their body sizes.

Isley I narrowed his eyes as he looked through Ottzinger. He hadn't seen any other way to get here. Why had Ottzinger left them, and where had he gone? "We were trapped with the bats!" he almost shouted.

"Bats?" said the professor. "Oh, dear, I didn't mean to... Say, what's that you've got? Let me see that skull."

Isley I and II reluctantly added their cranium to the pile.

"Sit down, you guys," Lakeisha said. "We were just talking about these skulls."

The Isleys sat down, but they were uneasy.

"None of these is the Mishigara Man, I'm afraid," Professor Ottzinger said, turning a skull over in his hands.

"How do you know?" B.J. asked. "Can you tell if a skull is from a man by its size? Humans are the most intelligent animal. Are human skulls the biggest?"

"Oh, no," said Ottzinger, "bigger cranium size doesn't necessarily mean more intelligence. A horse's head and cranium are much larger than a human's, and horses certainly aren't as intelligent as we are. Size alone doesn't tell the whole story."

Lakeisha spoke up quickly, "I could tell a horse's skull from a human cranium."

"Of course," Ottzinger answered. "That's an important point. The shape and appearance of the cranium is the first factor. It has to *look* like a human skull as well as to be the right size for a human. Then there are other factors...."

"So what kinds of skulls *are* these?" Isley I interrupted.

"The smallest one is a bird," said Lakeisha, "and then there's a large reptile, a goat and a human."

"Human?" said Isley I.

"A human being?" said Isley II.

"That's right," said Professor Ottzinger, "but it isn't the Mishigara Man, because it's had some dental work—and there were no dentists in Mishigara's time!"

"But who...how?" Isley I was stuttering.

"Take it easy," said B.J. "It's probably over a hundred years old and belonged to some miner, or..."

"Some explorer," finished Lakeisha.

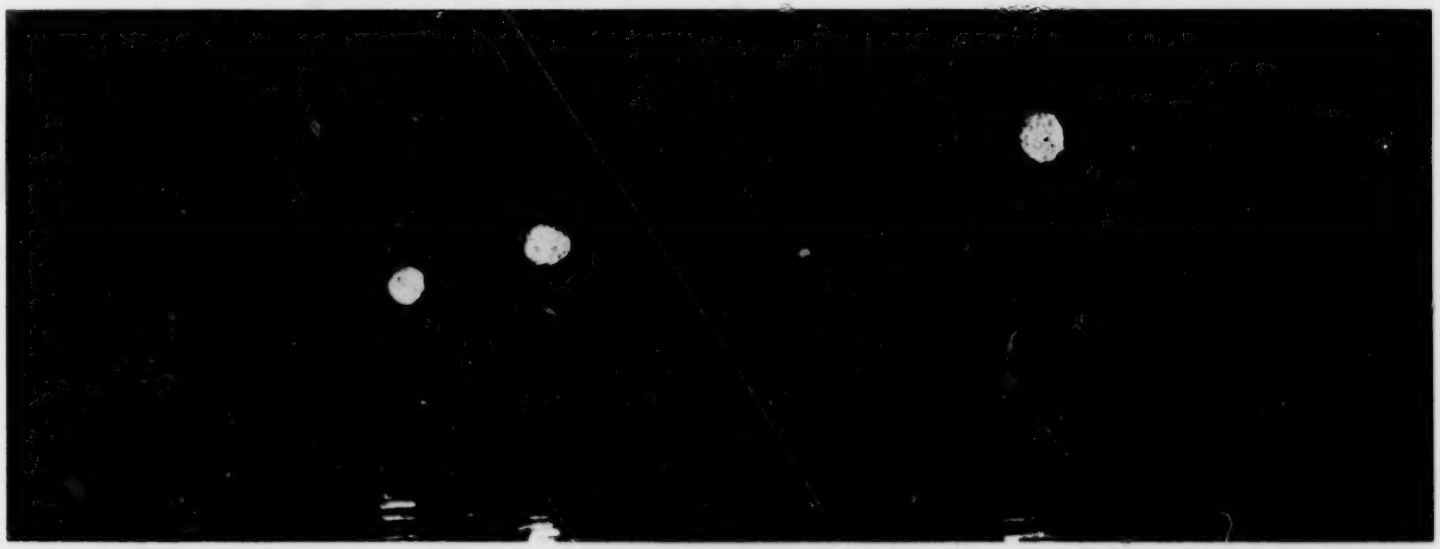
Isley I and II looked at each other. The cave was cold, damp and scary. They had been frightened by hundreds of bats and now they were sitting with a pile of skulls, one of which belonged to an *explorer*.

"What time do we go home?" Isley II asked.

Light at the End of the Tunnel

In the meantime, Kyle, Max and The Brain were wandering in a huge cavern. They couldn't even see the ceiling. Echoes sounded far away. They could hear bats flying high above, but they couldn't see them.

The boys might have been lost forever, except that Kyle had brought his father's infra-red binoculars. The super-binoculars allowed him to see in the dark, far beyond their flashlight beams. For the last fifteen minutes he had been leading the others, following a small glimmer of light he'd spied on a cliff, far off to their right.



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Finally, they approached the source of the light. Creeping silently to the edge of a ridge, they saw a man sitting before a small campfire. It looked like Professor Ottzinger. And it looked like he had the Mishigara Man in his hands!

Max's "Hello" echoed through the canyon.

The man looked up and saw the boys. Suddenly, like a big black bird of prey raising its wings, he leaped up, threatening the intruders who unexpectedly came upon him.

"Professor!" Kyle cried out. "It's only us, the NeuroExplorers!"

"Who?" Ottzinger called, towering over the campfire.

"Us—Kyle, Max, The Brain. Professor Ottzinger, it's *us*," Max said again.

Ottzinger tilted his head slightly and lowered his chin. Slowly he sat down, rubbing his neck with his free hand. In the other hand he tightly clasped a skull. "Oh, yes," he stammered. "I'm sorry. You startled me."

They advanced slowly toward the campfire. The Brain was uneasy.

"How did you get here?" Kyle asked. "I thought you were with the Isleys in the frontal sinus caves."

Ottzinger glared hard at Kyle. "Yes, well, we got separated, and I wound up here." Ottzinger looked around. The Brain was studying the maps.

"You found the skull?" Max asked, pointing to Ottzinger's possession. "Is it the Mishigara Man?"

Ottzinger stared straight ahead, giving no response.

"Could be," said The Brain, whirling around to face the suspicious man. "In fact, it is more likely that the skull is the Mishigara Man than that *you* are Professor Ottzinger!"

"Brain?" Max said. "What are you saying?"

"It is completely improbable that Ottzinger could arrive here from the frontal sinus caves so quickly. Not according to this map. Not unless he has developed a way to walk on water and over a bottomless chasm!"

Kyle looked at Max. "Is The Brain saying what I think he's saying?" Max swallowed hard and nodded.

The mysterious Ottzinger jumped and ran. No one dared to follow him.

Framed against ancient cave walls by scant firelight, three NeuroExplorers stood silently, trying to make some sense of what was going on.

Two Many Professors

The two girls and the Isleys were in the ethmoid cave waiting for Kyle, The Brain and Max to get there. Professor Ottzinger was standing to the side, talking with them about differences among the skulls they had found. "You NeuroExplorers are quite good. Quite smart. Maybe too smart," he said.

The girls and the twins fell silent. What did Ottzinger mean? "*Too* smart?" What was he talking about now?

Their wondering was suddenly interrupted by a noise—someone running toward them. A man burst in upon the group. It was Professor Ottzinger.... But the professor was already here! Now there were two Ottzingers!

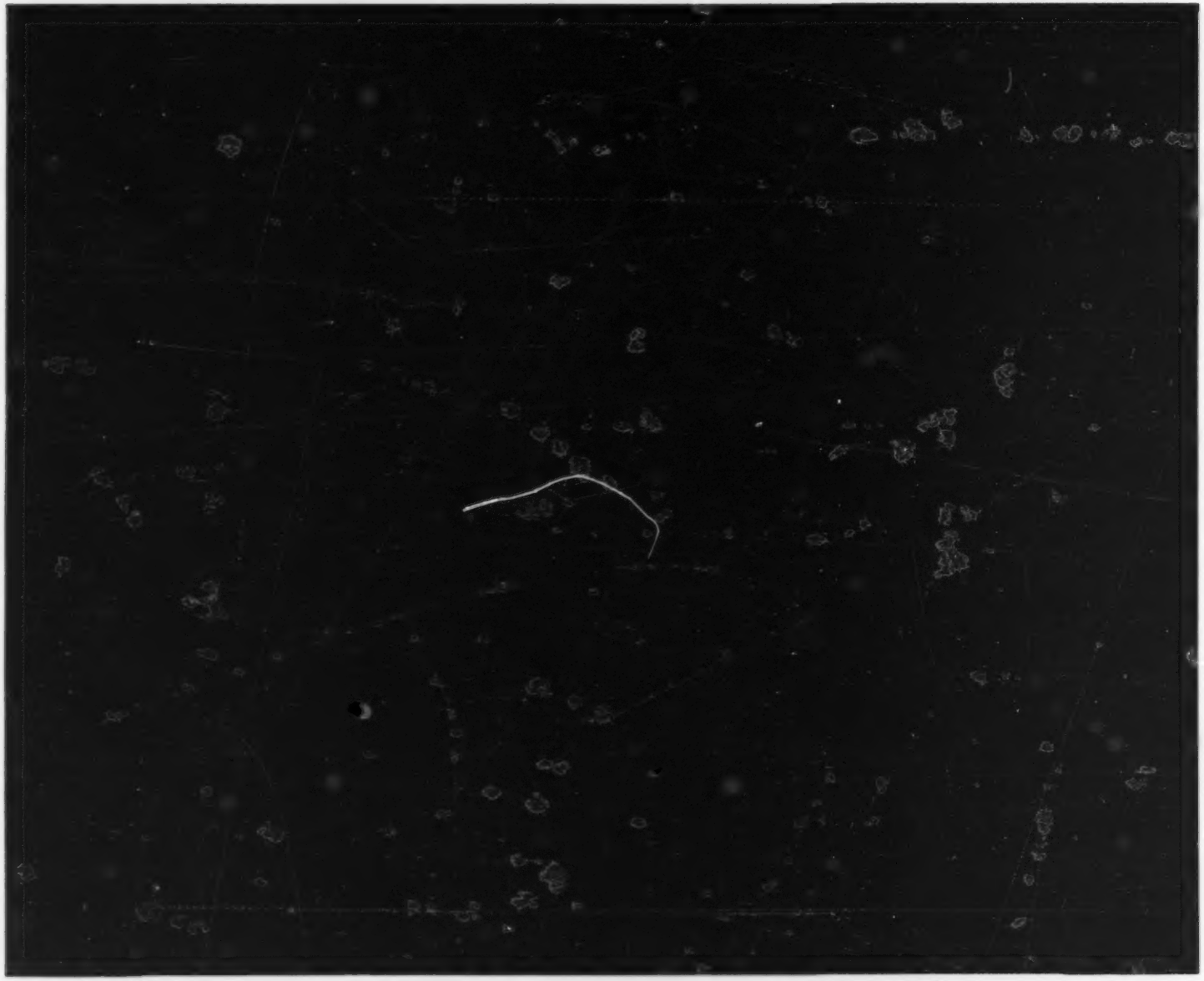
Two Ottzingers? There they were, like two reflections. Only, which one was real, and which one was the reflection?

Kyle, Max and The Brain arrived on the scene just in time to witness the amazing picture. They stopped and stood stone still. What was this double vision?

The Brain looked at the two Ottzingers and spoke. "Monozygotes," he said.

"Max," Kyle ordered, "translate!"

"Twins!" Max snapped back. "They're identical twins, just like the Isleys!"



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Kyle looked quickly from one Ottzinger to the other. They looked exactly alike, right down to the clothing—except for one item. The Ottzinger who just ran in was clutching a human-looking skull.

"The Mishigara Man!" B.J. yelled. The echo of B.J.'s words resounded a thousand times above their heads and beyond, shrinking to a small, distant whisper.

The Ottzinger without the skull spoke first. "Peter," he said, "I want the skull. Give it back now, and I'll let you go, no questions asked."

The other Ottzinger growled, "And who's going to make me? You and these Noorow explorers?"

Isley I and II jumped up, but Kyle held them back.

Professor Ottzinger held up his hand. "Easy, boys," he said. Then he turned back to his brother. "Peter, this is your last chance," he said.

"No!" his brother called out. "I discovered the skull and I'm going to keep it!"

"I thought we settled all that," the professor responded. "Credit was given to everyone who worked on the dig. But the skull belongs at the University."

"Not if I can help it," said his brother, holding the skull high above his head and backing away from the group.

Kyle had had about all he could take. Stepping forward, he spoke accusingly to Professor Ottzinger, "You haven't told us everything, Professor!"

Professor Ottzinger turned toward Kyle and smiled. "You're right, Kyle," he said, "and I'm sorry, but it was necessary."

Peter Ottzinger turned to run. Then, suddenly, the cave turned brilliant with light, practically knocking the NeuroExplorers off their feet. Peter Ottzinger stopped and slumped to his knees. The NeuroExplorers shielded their eyes.

Groping for an answer, they squinted through the glare. The sun hadn't broken into the Caves at Calicoon. Those were searchlights—police searchlights.

S1

S2

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A Plan for Mishigara Man

"My brother just couldn't accept that it was no single person's discovery, and that the find belonged to science," Professor Ottzinger said to the NeuroExplorers when they visited his office at Dargate a few days later. "He wanted to sell the skull to the highest bidder."

"I still don't understand why you needed *us*." Lakeisha said. "Why not just bring the police?"

The professor shook his head. "Peter's been very successful in keeping away from the police. I had to get him trapped somewhere. I guess I'd better tell you the whole story. I knew my brother would have hidden the skull somewhere in the Caves at Calicoon. I let him know that I was taking a group of students on a field trip to the Caves. If my hunch was right, he would be there to protect his precious skull."

"A school field trip? I'm insulted, I think," Lakeisha said.

"Oh no, quite the contrary!" Ottzinger said. "I didn't bring just any school kids. I brought the NeuroExplorers. Without your intelligence, courage and skills, I don't think we would have flushed Peter out."

"Right," said Isley I.

"Not you, Isley I," said Isley II. "He was talking about skill and intelligence." His brother poked him in the ribs.

"I'm sorry about the bats, Isleys," Professor Ottzinger said. "I didn't know that would happen. I had to go ahead to be sure of Peter's location."

"Well, your brother sure scared us when *we* found him," Kyle added.

"I had the police all around the caves," Ottzinger continued, "so I believed we were safe. Besides, Peter may be a bit greedy, but he's not a violent man."

"But why the Caves?" Lakeisha interrupted.

"My brother and I played there when we were children," Professor Ottzinger replied. "We even built some secret walls to hide passages. It was the most logical place for Peter to hide the skull."

The Brain, with a small, crooked smile, looked around the room and then at Professor Ottzinger. "There remains only one query," he said slowly, edging his way over to the prized skull. Everyone fell silent and looked at The Brain.

"Where's the *rest* of Mishigara Man? Shouldn't we embark upon an expedition to unearth the remainder of the skeleton?"

Not waiting for a translation, the group began to move toward him. "Let's make a plan," continued The Brain, "to extrapolate..."

Professor Ottzinger had to pull the NeuroExplorers, one by one, off of The Brain as his words faded into the noisy room.

Glossary

Alzheimer's disease (ALLZ-hy-merz diz-eez) - a disease, found especially in older adults, that destroys cells of the central nervous system so that people can no longer remember or think properly

archaeologist (ar-kee-AHL-uh-jist) - a scientist who studies the remains of past human life

bilateral (by-LA-ter-ul) - having two sides, as the right and left sides of the body

brain (BRAYN) - the control center of the central nervous system, located within the skull and attached to the spinal cord; the command center of the body

cerebrum (suh-REE-brum) - the large, domed top area of the brain where thinking, learning, memory, and decision-making occur

cranial bones (KRAY-nee-ul) - the bones that make up the skull

cranium (KRAY-nee-um) - the skeleton of the head except for the jaw bone

Darwin, Charles (DAR-win) - a naturalist in the 1800s who studied plants and animals around the world and is known for his book, "On the Origin of Species"

epilepsy (EH-pih-lep-see) - a condition brought about by sudden changes in the brain that affect a person's awareness and actions, often with jerking movements of the body and limbs, for short periods of time

ethmoid bones (ETH-moyd) - the bones forming the roof of the nasal cavity, containing air chambers and many small holes

ethmoid sinuses (ETH-moyd SY-nus) - small air-filled spaces within the ethmoid bones, on either side of the nose

fracture (FRAK-cher) - a break, especially of a bone

frontal bone (FRUN-tul) - the front bone of the skull, forming the forehead

frontal sinuses (FRUN-tul SY-nus) - air spaces, lined with mucous membrane, within the frontal bone above the eyes

gyri (JYE-rye) - the outward folds on the surface of the brain

impression (im-PREH-shun) - an indentation, or dent, in a surface

lacrimal bones (LA-kri-mul) - small bones at the inside edge of the eye sockets, with small openings to carry tears

maxillary bone (MAK-sih-lair-ee) - upper bone of the mouth which holds the upper teeth and forms the roof of the mouth; the upper jaw bone

maxillary sinuses (MAK-sih-lair-ee SY-nus) - air spaces in the maxillary bone, in the cheek area of the face

midline (MID-lyn) - an imaginary line that divides the body into right and left halves
monozygotes (mah-no-ZY-gotes) - identical twins
nasal (NAY-zul) - relating to the nose
nervous system (NER-vus sis-tum) - the brain, spinal cord and network of nerves in the body
neurologist (nu-RAHL-uh-jist) - a medical doctor specializing in the diagnosis and treatment of disease and injury in the nervous system
neurology (nu-RAHL-uh-gee) - a branch of medical science which deals with the nervous system
neuroradiologist (nu-ro-ray-dee-AHL-uh-jist) - a medical doctor who uses pictures of the inside of the body (X rays and others) to identify injury and disease in the nervous system
neuroscience (nu-ro-SY-ens) - a branch of science related to the study of the nervous system
neurosurgeon (nu-ro-SUR-jun) - a medical doctor who specializes in operating on the brain, spinal cord and nerves
neurosurgical nurse (nu-ro-SUR-ji-kul NURS) - a nurse who is part of the team of people who perform surgery on the nervous system with a neurosurgeon
occipital bones (ok-SIP-ih-tul) - bones that form the back of the skull
parietal bones (puh-RY-uh-tul) - a pair of bones that form the wall and roof of the skull
physician (fih-ZIH-shun) - a medical doctor
sinus (SY-nus) - a space or chamber containing air or fluid within the bones of the skull
skeleton (SKEL-uh-tun) - the framework of bones that support the body
skull (SKUL) - all the bones of the head, including the cranium and the facial bones
skullduggery (skul-DUG-er-ee) - trickery; underhanded behavior
sphenoid bone (SFEE-noyd) - a dragonfly-shaped bone on the inside of the skull behind the eyes
sphenoid sinuses (SFEE-noyd SY-nus) - cavities in the sphenoid bone, connecting with the nasal cavities
symmetrical (si-MEH-tri-kul) - having one side the same as the other side
temporal bones (TEM-puh-rul) - bones on both sides of the skull next to the forehead and the eyes, in the area of the temples and partly covered by the ears
tissue (TIH-shoo) - many cells of the same kind, joined together to do a specific job
zygomatic bone (zy-go-MA-tik) - the cheekbone

Grace Boyle was a teacher in Hempstead, New York for 20 years and received her M.S. degree in Elementary Administration from Hofstra University. She developed, coordinated and implemented a program for gifted and talented students in the Hempstead school system. Ms. Boyle has written curriculum materials for several textbook publishers, specializing in activity books that encourage children's critical thinking skills and stories that promote scientific curiosity. Currently, Ms. Boyle is a freelance writer. Her son, Dr. Thomas P. Boyle, a Florida radiologist, serves as consultant for her science-based writing.

T Lewis was born in Texas but has travelled extensively, living in such locales as Africa, Switzerland and Alaska. Currently, he lives in a small town in the state of Washington with his wife and young son. While his broad range of artwork has appeared in many formats, he is especially fond of creating illustrations for children. Recent books bearing his work are *Bedtime Rhymes from Around the World* and *Cinderella: The Untold Story*. He has drawn the Mickey Mouse comic strip for Disney Productions and is one of the creators of *Over the Hedge*, a comic strip in national syndication.

Faculty members in the Division of School-Based Programs at Baylor College of Medicine in Houston, Texas, have developed and revised instructional materials for the BrainLink® project. Judith Dresden, Barbara Tharp and Nancy Moreno have been working together at Baylor for several years on science education projects involving teachers and students from kindergarten through college. All are parents of teenage or grown children. As a team, they also have created instructional materials for the My Health My World™ project, which focuses on environmental health science for elementary school students.

Judith Dresden, originally from New York and New England, formerly conducted educational research and evaluation for public and private schools. Editorial work with a publishing company also led to her current interest in writing and editing stories and science activities for children. She directs the BrainLink project at Baylor and at regional centers around the country. Other projects involve promoting minority students' access to careers in science and the health professions.

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Nancy Moreno, originally from Wisconsin and Michigan, is a biologist who specializes in botany. She spent considerable time studying neotropical plants in Mexico before completing her doctoral degree at Rice University. Current interests include involving scientists in pre-college education. She oversees the science content of Baylor's elementary curriculum development projects and directs the My Health My World project, which builds upon her special interests in ecology and environmental issues.

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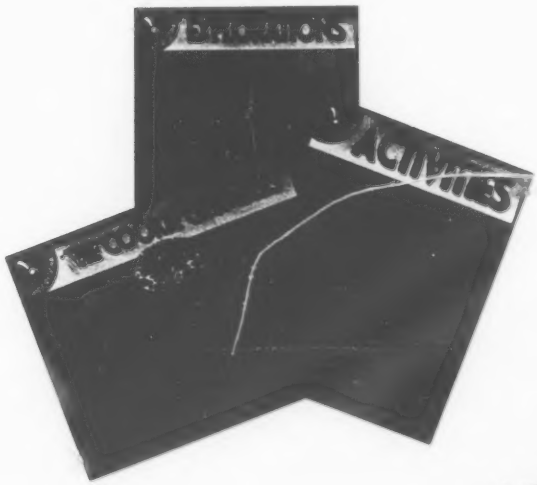

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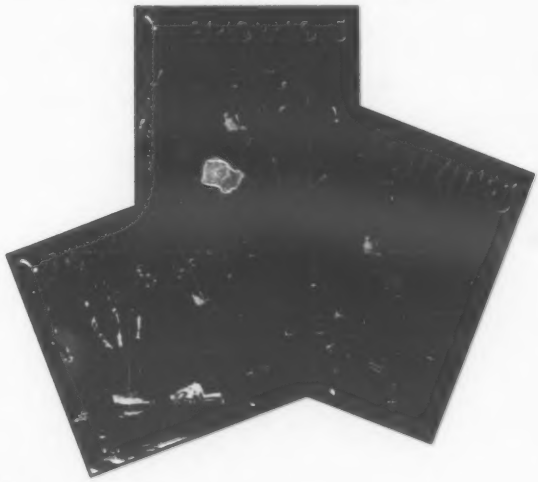

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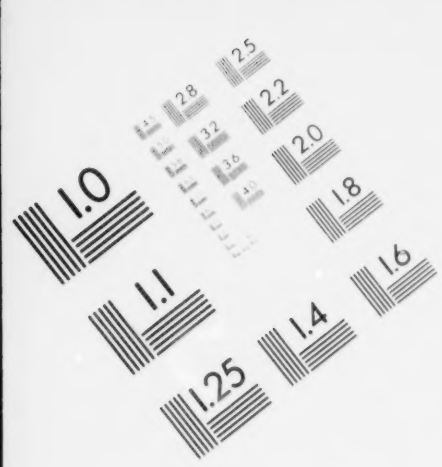

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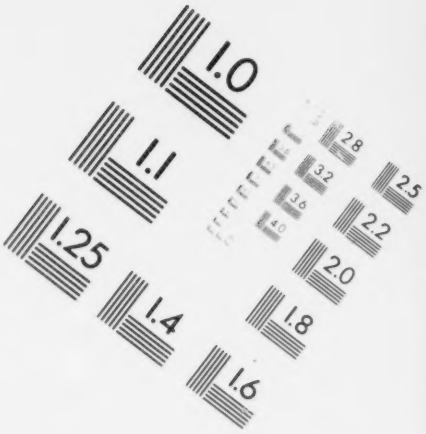

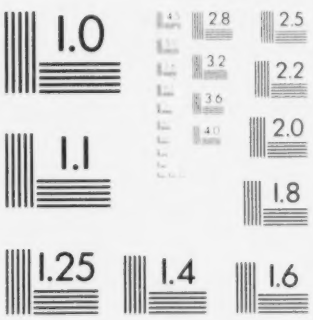

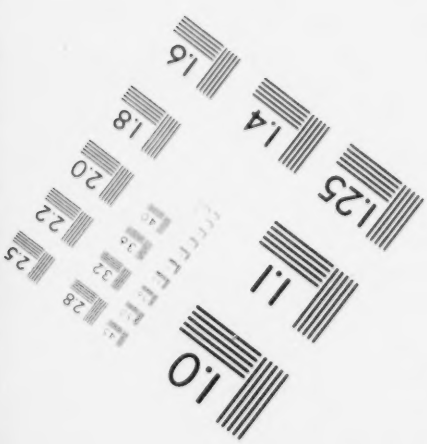

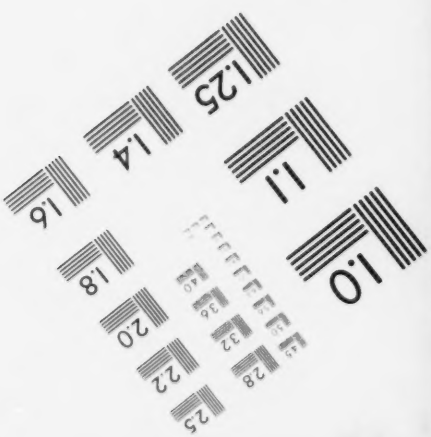

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Science and Health for Kids!

These BrainLink Activities are designed to be used with other components of the Brain Comparisons unit:

BrainLink Adventures
Skullduggery: The NeuroExplorers™ in a Case of Cranium Confusion

BrainLink Explorations
Brain Comparisons

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BrainLink Project Director: Judith Dresden, M.S.
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"The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind."

James D. Watson
from *Discovering the Brain*
National Academy Press
1992

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ABOUT BRAINLINK - Science and Health for Kids!

The BrainLink Project's exciting *Activities*, *Explorations* and *Adventures* "link" students, teachers and parents to advanced knowledge of the brain and nervous system and to vital science and health information. Prepared by teams of educators, scientists and health specialists, each BrainLink unit focuses on a different aspect of the brain and the nervous system. The activity-based, discovery-oriented approach of the BrainLink materials is aligned with the *National Science Education Standards* and the *National Health Education Standards*.

The three components of each BrainLink unit help students learn why their brains make them special.

- *BrainLink Adventures* presents the escapades of the NeuroExplorers Club in an illustrated storybook that also teaches science and health concepts.

- *BrainLink Explorations for Children and Adults* is a colorful mini-magazine full of information, activities and fun things to do in class or at home.

- *BrainLink Activities - Guide for Teachers* presents activity-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.

BrainLink materials offer flexibility and versatility and are adaptable to a variety of teaching and learning styles.

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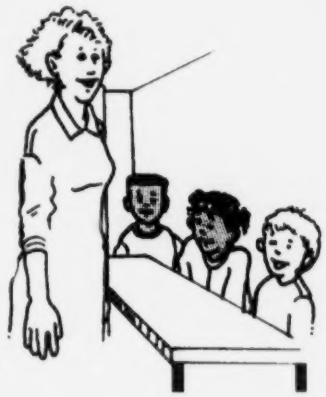
WHERE DO I BEGIN?

The *Adventures*, *Explorations* and *Activities* components of each BrainLink unit are designed to be used together to introduce and reinforce important concepts for students. To begin a BrainLink unit, some teachers prefer to generate students' interest by reading part or all of the *Adventures* story. Others use the cover of the *Explorations* mini-magazine as a way to create student enthusiasm and introduce the unit. Still others begin with the first discovery lesson in the *BrainLink Activities - Guide for Teachers.*

If this is your first BrainLink unit, you may want to use the pacing chart on the following page as a guide to integrating the three components of the unit into your schedule. When teaching BrainLink for 45 to 60 minutes daily, most teachers will complete an entire BrainLink unit with their students in two to three weeks. If you use BrainLink every other day or once per week, one unit will take from three to nine weeks to teach, depending on the amount of time you spend on each session.



The *BrainLink Activities - Guide for Teachers* provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of all materials, estimates of time needed to conduct activities and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. The final activity in each *BrainLink Activities - Guide for Teachers* is appropriate for assessing student mastery of concepts.

Using Cooperative Groups in the Classroom

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides an organized setting for group interaction and enables students to share ideas and to learn from one another. Through such interactions, students are more likely to take responsibility for their own learning. The use of cooperative groups provides necessary support for reluctant learners, models community settings where cooperation is necessary, and enables the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. There are materials to be managed, processes to be performed, results to be recorded and clean-up procedures to be followed. When students are "doing" science, each student must have a specific role, or chaos may follow.

The Teaming Up model* provides an efficient system. Four "jobs" are delineated: Principal Investigator, Materials Manager, Reporter, and Maintenance Director. Each job entails specific responsibilities. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities, so that each student has an opportunity to experience all roles. Teachers even may want to make class charts to coordinate job assignments within groups.

Once a cooperative model for learning has been established in the classroom, students are able to conduct science activities in an organized and effective manner. All students are aware of their responsibilities and are able to contribute to successful group efforts.

* Jones, R. M. 1990. Teaming Up! LaPorte, Texas: ITGROUP.

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Brain Comparisons
Sample Sequence of Activities, Adventures and Explorations

The components of this BrainLink unit can be used together in many ways. If you have never used these materials before, the following outline might help you to coordinate the Activities described in this book with the unit's *Adventure* story (*Skullduggery*) and *Explorations* mini-magazine (Brain Comparisons).

Similar information also is provided for you in the Links section of each activity in this book.

Activity	Concepts	Class Periods to Complete Activity	Links to Other Components of Unit	
			Adventures: Skullduggery	**Explorations: Brain Comparisons**
1. Did You Know?	The brain is the command center of the body. The brain has three parts.	1	**Read:** Calling All NeuroExplorers; Who Took the Mishigara Man?; Ottzinger's Plan	Gray Matters (p 2); Brains at the Supermarket (p 6)
2. Build a Skull	The brain is shielded by the skull, which also needs protection.	3	**Read:** Preparing for the Worst; The Caves at Calicoon	Use Your Brain - Promote Your Health (p 4); Your Colossal Cranium (p 8)
3. Good Wrinkles	Wrinkles allow more cerebral cortex to fit into the skull and correlate to higher intelligence in animals.	1	**Read:** Problems in the Frontal Sinus; Snakes in the Sphenoid	Gray Matters (p 2); Amazing Brains (p 3); Knead a Brain (p 5)
4. Comparing Brains	The size and shape of the cerebrum, cerebellum and brainstem differ among animal species.	1 or 2	**Read:** The Brain Runs Into a Wall; Sorting Skulls	Can You Match the Animal to Its Brain? (cover); Gray Matters (p 2); The Neuro Side (p 7)
5. How Much Brain Do You Need?	The size of an animal's brain relative to its body size is a predictor of intelligence.	2	**Read:** Light at the End of the Tunnel; Two Many Professors	Can You Match the Animal to Its Brain? (cover); Gray Matters (p 2)
6. Create a Brain	Summary and assessment activity	1	**Read:** The End of Darkness; A Plan for Mishigara Man (concludes story)	Careers for NeuroExplorers (p 7); Review Gray Matters (p 2)

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Materials

You will need the following materials to teach this unit.

BrainLink supplies

- BrainLink Balloons* or 11-inch helium quality balloons (one per student plus a few extras for demonstrations) (Activities 1 and 2)
- BrainLink Molds* to prepare cat and rabbit brain models AND/OR BrainLink Models* of cat and rabbit brains (models and molds are optional for the teaching of Activity 4: Comparing Brains)
- quick setting plaster* or other plaster for making brain models from BrainLink Molds (optional for Activity 4)

* See list at right.

Classroom supplies

- container of cooked oatmeal, soft butter or shortening (Activity 1)
- replica of a human brain and skull (optional) (Activity 1)
- red, yellow and blue markers (one set per student or group of students) (Activities 1 and 4)
- used packing materials such as boxes and other containers, bags, tape, bubble wrap, egg cartons, etc. (Activity 2)
- several rolls of masking or clear tape (Activities 2 and 3)
- scissors (one per student or group) (Activities 2 and 3)
- sheets of paper at least 9 inches by 9 inches (one per student or group) (Activity 3)
- sheets of newspaper (one per student or group) (Activity 3)
- rulers (one per student or group) (Activity 3)
- small box of paper clips (Activity 3)
- plastic cups and popsicle sticks for mixing plaster if students will be making their own brain models (Activity 4)

BrainLink® Supplies:

- BrainLink printed materials
- BrainLink balloons (optional)

- BrainLink Molds for creating cat and rabbit brain models (optional)

- BrainLink Plastic Models of cat and rabbit brains (optional)

- Quicksetting plaster (optional)

Call 1-800-969-4996 for information about BrainLink supplies.

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Did You Know?

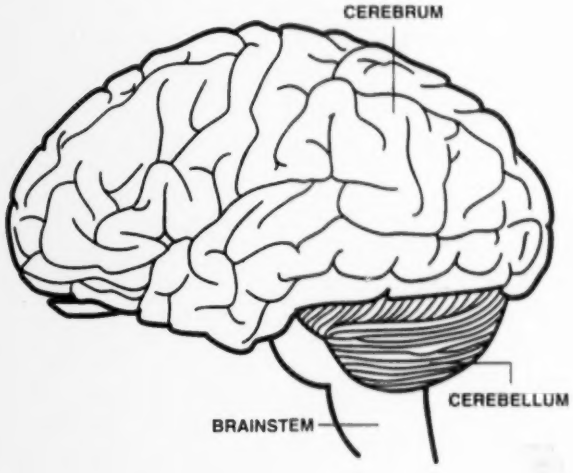
BRAINLINK BACKGROUND (for the teacher)

Did you ever wonder what a human brain really looks like? How much it weighs? What it feels like? Most of us will never see or touch a real brain, but we can capture much of the excitement of neuroscience while teaching some simple concepts about the brain.

The *brain* is the command center of the body. It is enclosed within the skull dome or *cranium*, the bony shell that protects it and also forms the shape of the head. The brain is further protected by a cushion of fluid and is covered by three thin but tough membranes called *meninges*.

The brain is the most complex organ of the body. It has three major parts, each of which plays a particular role. The *brainstem* controls automatic activities of the body, such as heartbeat, digestion, breathing, swallowing, coughing and sneezing. It is connected to the spinal cord. The *cerebellum* sits at the back of the brainstem. It helps the muscles work together for coordination and learning of rote movements. It controls the sense of balance. The largest part of the mammalian brain, the *cerebrum*, enables one to think, learn, remember, feel sensations and emotions, and move muscles voluntarily.

The surface of the cerebrum has wrinkles, called *gyri*, which enable more cerebral tissue to fit into a limited space. More wrinkles on the cerebral surface are thought to correlate with higher intelligence levels among various animal species.



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ACTIVITY 1

CONCEPTS

- The brain is the command center of the body.
- The brain has unique physical characteristics.
- The brain has three major parts, each with a special role.
- The brain is protected by the skull.

OVERVIEW

Students are introduced to the brain, the most complex organ of the body, and explore some of its properties.

SCIENCE & MATH SKILLS

Observing, estimating and measuring

TIME

Preparation: 10 minutes
Class: 30-45 minutes

MATERIALS

- BrainLink balloons* or 11 inch helium quality balloons
- copies of "Brain Diagram" on page 5 (1 per student)
- cooked oatmeal, soft butter or shortening
- source of water from a tap to fill balloon
- yellow, red and blue crayons or markers
- human brain/skull model (optional, if available)

* see page vi

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The general structure of all mammalian brains (for example, rabbit, cat, human) is similar. Each has three major regions—the cerebellum, the cerebrum and the brainstem. As the needs and behaviors of different animal species have changed over long periods of time, so too have their brains. Cerebellums and brainstems differ among mammals, mainly in size. Cerebrums, on the other hand, vary widely in both size and surface appearance. In addition, parts of the brain that are used more frequently or control important senses tend to become larger or more developed. (We will study this in more depth in Activities 3, 4 and 5.)

Animals' brains fit snugly inside their skulls. Brains are protected by the meninges and the fluid that surrounds the brain, but most of the protection is afforded by the skull, as we shall learn in Activity 2. There is a close relationship between the shape and size of the brain and the shape and size of the cranium.

CAT

RABBIT

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

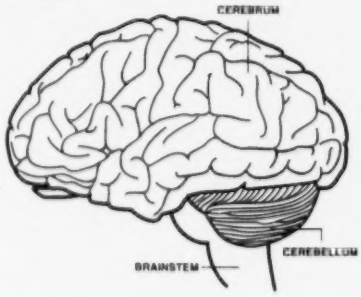
Skullduggery chapters:

- Calling All NeuroExplorers (see science box on page 3)
- Who Took the Mishigara Man?
- Ottzinger's Plan (see science box on page 6)
- NOTE. If this is your students' first BrainLink Adventure, have them read the introductory sections of the book—The Beginning and The Club Members—before continuing with the chapters listed above.

Explorations:

- Gray Matters (page 2)
- Brains at the Supermarket (page 6)

HUMAN



SET-UP

This activity is teacher-directed and is best presented as whole class instruction.

Prior to class, fill the "brain" balloon with water. To do this, first stretch the balloon. Then fill it with water by placing the open end of the balloon over a faucet until it contains approximately three pounds (48 ounces or 1450 ml) of water. Use a scale or compare the balloon to something of appropriate weight to estimate when you have reached three pounds.

Brain balloon filled with water

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PROCEDURE

1. Ask your students to tell you what they know about the brain. On the board, make a list of things the students think they know and of things they would like to find out. To help them along, you might ask questions, such as:

   - *Where is the brain located?*
   - *How much would you predict the average brain weighs?*
   - *What color do you think it is?*
   - *What would it feel like if you touched it?*

   Explain to students that even though scientists have learned much about the brain, there still are many unanswered questions. This lesson will help them learn about the physical properties of the brain.

2. Bring out the "brain" balloon and have a student assistant hold it in his or her hands. Use the BRAIN FACTS listed on this page to expand upon students' comments. You might say something like:

   - *Did you know that the average brain weighs about 1.45 kg (three pounds)? That is about the same weight as this balloon filled with water.* (Allow students to feel the weight.)
   - *Did you know that the brain is about the consistency of cooked oatmeal, shortening, or butter at room temperature?* (Allow students to touch whichever of these you have available.)

3. Mention the three major parts of the brain: brainstem, cerebellum and cerebrum. Ask, *Did you know that each part of the brain has a special job to do?* As you introduce the three major parts of the brain, locate each on the balloon and outline it with a marker to clarify the position. Refer to the Brain Diagram student sheet.

   The brainstem is located at the back of the brain and is connected to the spinal cord. The cerebellum is found at the back of the brainstem. The cerebrum, the largest section of the brain, has many wrinkles. If you look at the brain from the top, there are two distinct halves or hemispheres.

4. Explain that the wrinkles printed on the balloon represent folds in the surface. They are not smooth areas as they appear on the balloon. These wrinkles—gyri—enable needed brain material to fit into a limited space. (Activity 3 in this unit illustrates how this is accomplished.)

BRAIN FACTS

- The brain is the command center of the body.
- An average human brain weighs about three pounds.
- Brain tissue is about 80% water.
- Some people refer to the brain as "gray matter." If you look at the brain from the outside, it looks like a mass of grayish-pink wrinkles.
- The texture of the brain is something like cooked oatmeal, or butter at room temperature.
- The brain is divided into left and right halves.
- The brain has three main parts: brainstem, cerebellum and cerebrum.
- Each part of the brain has a specific job to do.
- The brain contains about 100 billion neurons. This number is comparable to the number of stars in the milky way.

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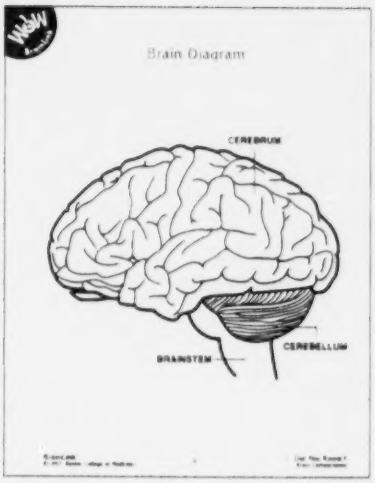
5. If one is available, introduce a human brain model. Relate the concepts you covered earlier to the model and once again tie them back to the students' initial observations. Possible lead questions might be:

   - *Would the human brain really feel the same as this model? Is it harder than the model, or softer?*
   - *Can you identify the three parts of the brain from this model? What about the two halves, or hemispheres?*
   - *Do you think all animals with backbones have brains like human brains?*
   - *What is the primary source of protection for the brain?*
   - *How is the brain positioned in the skull?*
   - *Do you think it is possible for a large animal to have a small brain? Is it possible for a small animal to have a large brain?*



6. Have students color their copies of Brain Diagram so that the cerebrum is yellow, the cerebellum is red, and the brainstem is blue. (These colors correlate with the illustrations in the Explorations component.) Relate the areas on the diagram to those on the brain model or on the water balloon.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- The human brain weighs about three pounds. What other things can you find that also weigh around three pounds? Are the additional things about the same size as your brain or the water balloon "brain?" Why do you think this might be? Why do you think that the water balloon "brain" is about the same size as a human brain?
- Notice the different sizes and shapes of the brains depicted on the cover of the *Explorations* component of this unit. In what ways are the brains similar? In what ways are they different?

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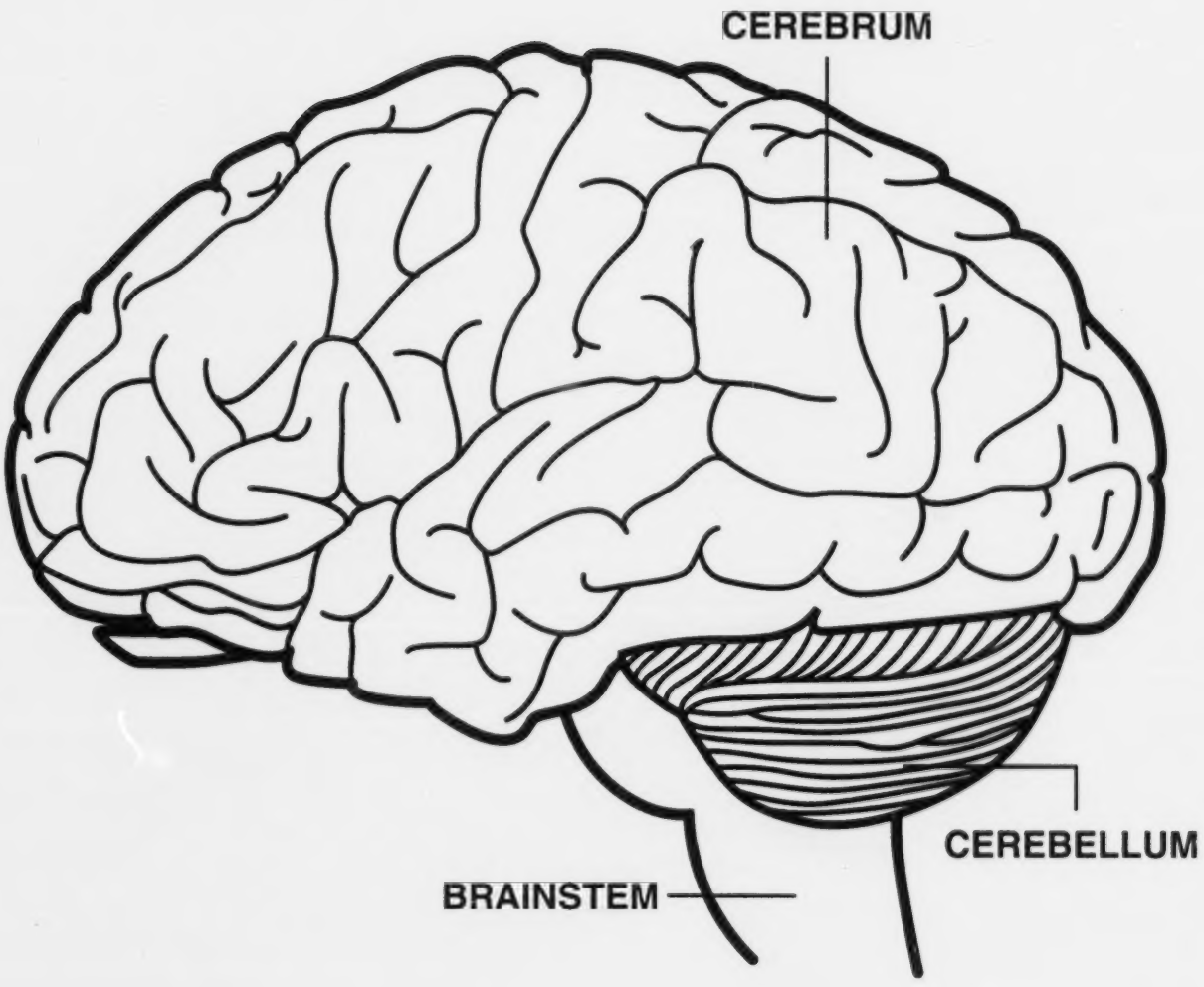
Brain Diagram



Build a Skull

BRAINLINK BACKGROUND (for the teacher)

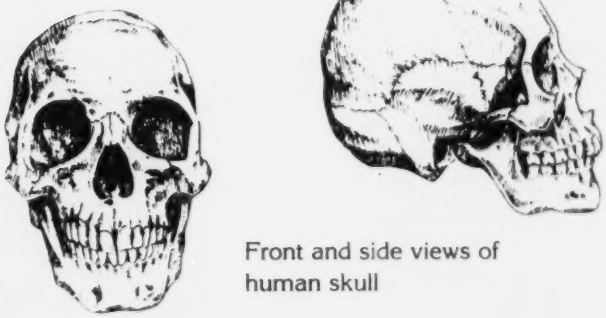
Skull Facts

The skull, the body's most complex bony structure, is comprised of 22 bones. It forms a hard, protective covering around the brain. Inside the skull, the brain also is supported by a liquid cushion—the *cerebrospinal fluid*. The fluid protects the brain and spinal cord by absorbing shock waves from blows and falls.

Eight bones compose the part of the skull that covers the bulk of the brain. Together, these form the brain's protective, bony "helmet," known as the *cranium*. Because its top is curved into a dome, the cranium is self-bracing. This allows the bones to vary from thick to thin and yet, like an eggshell, the cranium remains very strong for its weight.

A baby is born with a soft spot, a place on the top of the head where the bones of the skull have not yet grown together. If the bones were fused, they might be broken during birth. Instead, they are able to move. Also, further growth of the brain would be impossible if the bones of the skull were fused at birth.

The bones of the skull meet at irregular, linear joints called *sutures*. Even though the bones fuse in later life, the joints remain visible. The jagged structure of these bones provides extra strength to the skull because the edges lock together more securely than would two smooth edges.



Front and side views of human skull

ACTIVITY 2

CONCEPTS

- The skull protects the brain.
- The skull also needs protection.

OVERVIEW

Students will create and test protective covers for water balloon "brains" using various recycled materials.

SCIENCE & MATH SKILLS

Measuring, observing, predicting, modeling and inferring

TIME

Preparation: 10 minutes
Class: one session of 30 minutes to present skull facts and plan design; one session of 45 minutes to build and present skulls; one session of 30 minutes to test skulls outside and discuss results

MATERIALS

Each group of students will need:

- BrainLink balloon* or 11 inch helium quality balloon
- copies of "Skull Diagram" and "Front View of Skull" (pages 10 and 11)
- source of water from a tap
- tape and/or glue
- recycled materials such as boxes and other containers, bags, bubble wrap, egg cartons, milk cartons, cloth, etc.

* see page vi

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Of all the bones of the skull, only the *mandible*, or jawbone, is freely movable. In addition, the mandible is the largest and strongest bone of the skull.

The skull has about 85 openings. The most important openings include those that allow passage of the spinal cord and the major blood vessels, and those that form holes for the eyes and nose.

Sinuses

The skull has four pairs of air-filled cavities (*sinuses*) actually within the skull bone. One sinus of each pair is on each side of the skull. Three sets (maxillary, ethmoid, and sphenoid) are present at birth. Frontal sinuses develop around the age of eight. Each sinus is connected to the nasal cavity by a tiny tunnel (duct) about the size of a pencil lead. These ducts easily can become blocked, leading to headache, fatigue, congestion, and face pain, all signs of sinus infection. Sinuses are lined with thin layers of tissue (or membranes) that filter and humidify the air we breathe. Sinus problems arise when those tissues become infected or inflamed.

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

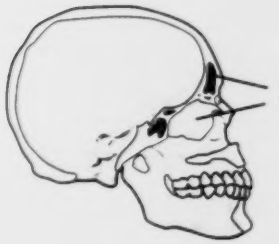
Skullduggery chapters:
- Preparing for the Worst (see illustration of skull on page 7, and science boxes on pages 8 and 9)
- The Caves at Calicoon (see science box on page 12)

Explorations:
- Use Your Brain - Promote Your Health (page 4)
- Your Colossal Cranium (page 8)

SET-UP

Several days before beginning this activity, have students bring clean recyclable materials to class. They will use the materials as they work in teams to build skulls for water balloon brains. Three class periods should be devoted to this activity, one to plan the skulls, a second for construction and a third to complete and test the "skulls."

Students should work in groups of 2-4 to plan and build their skulls.



Cross-sectional view of skull

Injury Facts

- Every 15 seconds, a head injury occurs in the U.S.A.
- More head injuries occur in cars than in all other types of accidents combined.
- Traumatic brain injury is the fastest-growing type of injury in the U.S.A.
- Falls are the primary cause of head injuries in children under five years of age.
- Bicycle accidents are the primary cause of head injuries in children 5-12 years of age.
- Each year, 1,200 bicyclists are fatally injured and over one half million bicycle-related injuries are treated in hospital emergency rooms.
- The most common cause of death and serious injury from bicycle accidents is injury to the brain.
- A bicycle helmet is the best protection from an accident that could kill or disable for life.
- Helmets reduce, by 85%, the risk of brain injury from accidents involving bicycles, motorcycles, etc.
- When purchasing a bicycle helmet, look for a sticker inside certifying that it meets the safety standards of the SNELL Memorial Foundation or the American National Standards Institute.

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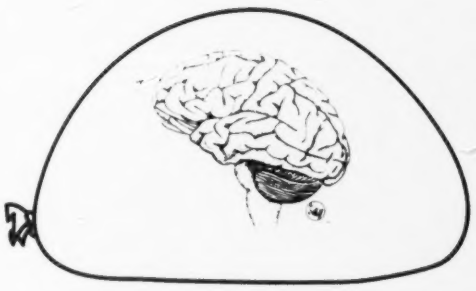
PROCEDURE

Planning (30 minutes)

1. Prepare two water "brain" balloons, as described in Activity 1: Did You Know? Take the class outside. Demonstrate to students how easily the "brain" balloon can be damaged by forcefully throwing one water balloon onto a hard surface. The balloon should burst. Point out that the brain is about as fragile as the water balloon. Ask students to imagine whether the unprotected water balloon brain would survive a fall from a bicycle or a slowly moving car.

2. Hold the second balloon in front of the students as you challenge them to create a protective "skull" for a water balloon out of materials that they have brought from home or that you have provided.

3. Let each group brainstorm ways to make a strong, resistant skull to protect their water balloon "brain." Ask them to consider, *What materials are available that would give the "brain" protection? How could the materials best be combined to form that protection?*



Brain Balloon

Building the Skulls (45 minutes)

1. Give each group of students a "brain" balloon. Tell them first to stretch the balloon, then to fill it slowly with water by placing the end over a faucet. The balloon should contain about three pounds (1.45 kg) of water. Place a pre-filled balloon next to the sink to give children an idea of how much water they will need in their balloons, OR have them use a scale or balance to adjust the amount of water to approximately three pounds. When they have roughly the correct amount of water in each balloon, have them tie the end. Warn students to hold the balloons from the bottoms to avoid breakage.

2. Have the groups construct skulls around the balloon "brains."

3. When the students have finished working, each group should present its "skull" to the class. The students should explain their choices of materials and construction techniques.

Testing the Skulls (30 minutes)

1. Test the "skulls" outside. Using an unprotected water balloon, demonstrate the effects of dropping a balloon onto grass, throwing a balloon onto grass, dropping a balloon onto a hard surface and throwing one forcefully onto a hard surface. Discuss why the water balloons might or might not break in those different situations.

Dropping the protected brain balloon

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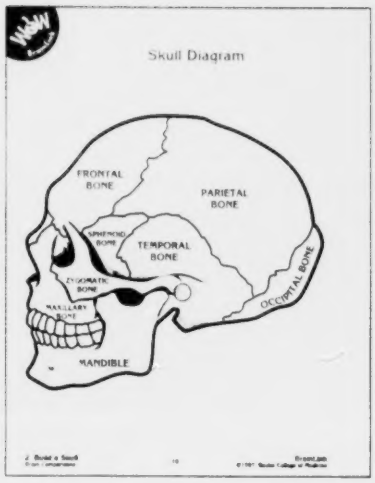
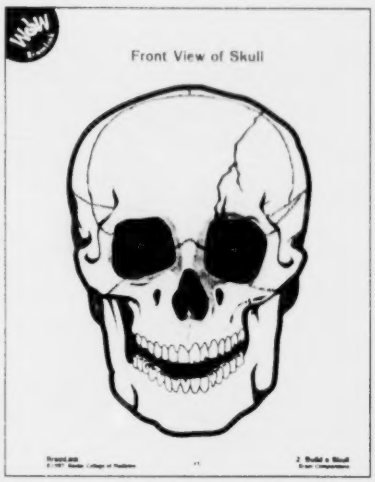
2. Let the students test their "skulls." One skull should be tested at a time, so that the entire class can watch. Have each group test the "skull" on different surfaces as described above. Discuss the results with the students. You might mention that the brain balloon is not exactly like a brain, but that it does illustrate the fragile nature of the brain. This exercise also shows that even a well-designed skull cannot protect the brain against everything.



3. Use the information in the BRAINLINK BACKGROUND and the following questions to encourage a discussion after completing the activity. Have students think about the need for wearing a helmet during activities like baseball, bicycling, rollerskating, rollerblading, and motorcycling. Give each student a Skull Diagram and Front View of Skull sheet for reference during the discussion.

   - *Why does the brain need a skull?*
   - *What is the human skull made of?*
   - *What can you do to help protect your brain? Your skull?*
   - *When do you think it is important to wear a helmet?*
   - *Why do you think we have sinuses?*
   - *How can our sinuses cause us problems?*



4. Describe the sinus cavities (see above) and their function. Mention that the caves in *Skullduggery*, the corresponding BrainLink Adventures story, are shaped like sinus cavities.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Do you think we should walk around with helmets on our heads all the time to protect our brains? Why is this a good idea? Why is this not such a good idea?
- Woodpeckers have many air spaces in their skulls. Why might this be so? Consider what they do for a living.
- The curved bones at the top of the skull form a strong arching structure. Where else do you see materials put together in this way?

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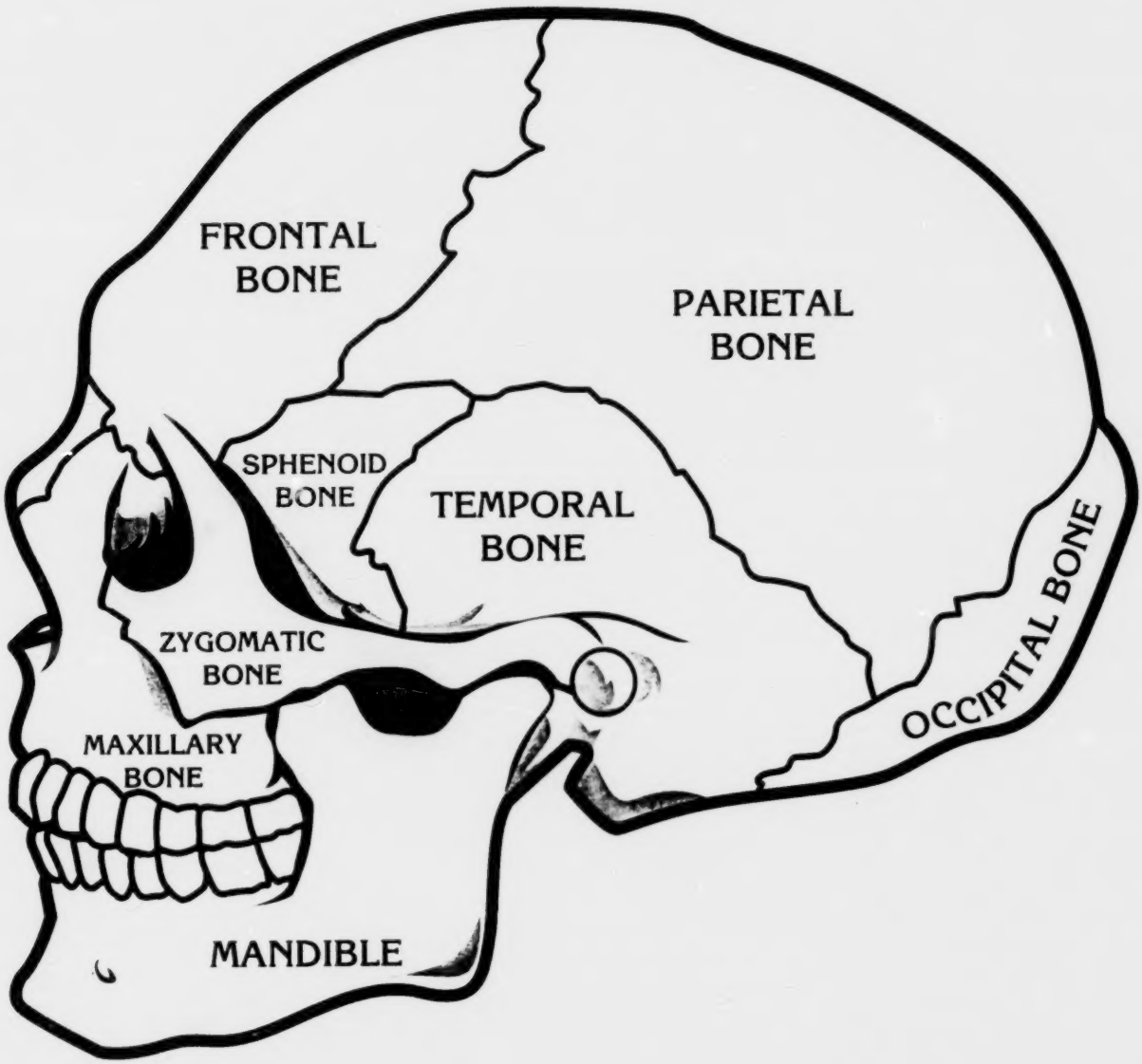
Skull Diagram



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Front View of Skull

Good Wrinkles

BRAINLINK BACKGROUND (for the teacher)

Animal intelligence is a fascinating topic. Experts believe that the more brain mass a species has relative to its body weight, the smarter it is. (Also see Activity 5: How Much Brain Do You Need?) It also generally is accepted that the ability to perform complex tasks is related to the number of creases or folds (gyri) found on the surface of the cerebrum.

Gyri evolved through the ages to accommodate increasing amounts of cerebral tissue within the limited space inside of the cranium, as animals developed higher level thinking skills. Just as one would fold something large to fit it into a small space, the brain's cerebral cortex over time has folded upon itself in order to fit more and more tissue into the cranium. The cerebral cortex consists of a sheet of nerve cells about 5 mm thick, forming the uppermost layers of the cerebrum.

In this activity, students will use a sheet of newspaper to represent the surface area of the human cerebrum. They will attempt to fit the newspaper within a smaller space without hiding any of the information written on the page. They will relate their findings to the "folding" of the surface of the cerebrum.

Large numbers of folds are quite common in the brains of many mammals. Human beings have large numbers of gyri, as do some other mammalian species (such as the chimpanzee, orangutan, gorilla, dolphin and whale).

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

***Skullduggery* chapters:**
Problems in the Frontal Sinus
Snakes in the Sphenoid (see science box on page 18)

Explorations:
Gray Matters (page 2)
Amazing Brains (page 3)
Knead a Brain (page 5)

SET-UP

Students may work individually or in small groups.

PROCEDURE

1. This is intended to be a discovery lesson. Therefore, without any introduction, give each student or group of students a large piece of plain paper and ask them to measure and cut it

ACTIVITY 3

CONCEPTS

- Wrinkles in the cerebrum correlate to higher intelligence in animal species.
- Wrinkles evolved to allow more cerebral cortex to fit within the skull.

OVERVIEW

By using paper to represent the surface areas of the cerebrum and the skull, students will learn about the significance of wrinkles on the surface of the mammalian cerebrum.

SCIENCE & MATH SKILLS

Measuring, comparing measurements, problem solving and drawing conclusions

TIME

Preparation: 10 minutes
Class: 30-45 minutes

MATERIALS

Each student or group of students will need:

- copy of "Mammalian Brains" on page 14
- large sheet of plain paper (at least 9 inches by 9 inches)
- full size sheet of newspaper
- scissors
- tape, paper clips and/or glue
- ruler or tape measure

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to approximately 23 cm x 23 cm (9 in x 9 in). Ask older students to calculate the surface area of the sheet and to write the result (529 cm^2 or 81 in^2).

2. Give each student or group of students a sheet of newspaper, which they should measure and cut to about 49 cm x 49 cm (19.2 in x 19.2 in). Ask them to calculate the surface area of this sheet and to write the result (2,401 cm^2 or 369 in^2).

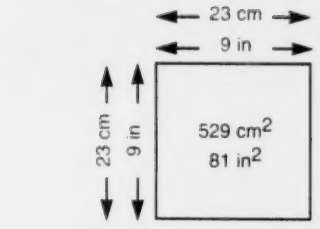
3. Ask the students to find the difference between the areas of the sheets (2,401 - 529 = 1,872 cm^2 or 369 - 81 = 288 in^2).

4. Challenge each group to find a way to make the larger piece fit evenly over the smaller piece **without cutting**. Subtly encourage the students to crinkle or accordion-fold the large sheet so that all the surface area of the newsprint remains visible. It can be fastened to the edges of the smaller sheet, if desired. Give students an opportunity to experiment.

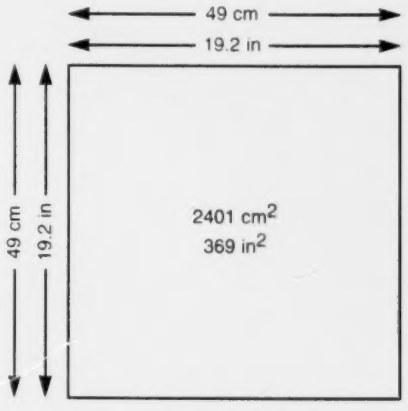
5. Once students have finished working, let them share and discuss their solutions.

6. Now, tell students that the smaller plain sheet has about the same surface area as the helmet-shaped part of an average human skull. Tell them that the newspaper sheet has about the same surface area as an average human cerebrum. Explain that the sheets of paper served as models for the top of the skull and the cerebrum, respectively. Discuss how the problem of fitting more cerebral tissue (thinking part of the brain) into a limited amount of space was solved during the course of evolution. *Increasing amounts of cerebral tissue were folded into wrinkles, allowing the brain to store and process more information in a smaller space.*

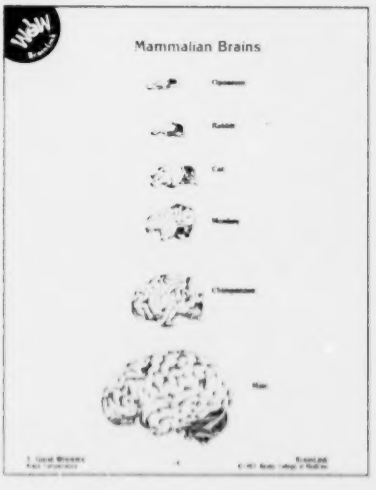
7. Point out that the number of gyri differ among animal species. Discuss these differences in terms of the relative intelligence of animals as described in BRAINLINK BACKGROUND above. Pass out copies of the Mammalian Brains sheet. Discuss the number of gyri present in each brain and what the students know about the activities and relative intelligence of members of each species.



Small sheet



Large sheet



BRAIN JOGGING

Here is another idea for you and your students to explore.

What other parts of your body also use wrinkling or folding as a strategy to fit into a smaller space? Where **else** do you see folding or wrinkling used in a similar way?

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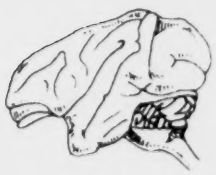
Mammalian Brains

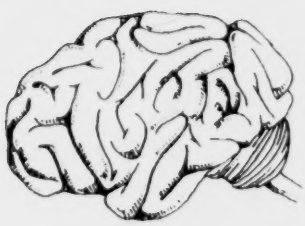
Opossum

Rabbit

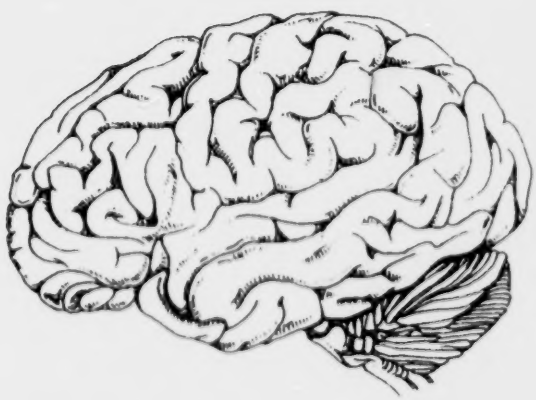
Cat



Monkey



Chimpanzee



Man

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Comparing Brains

BRAINLINK BACKGROUND (for the teacher)

Brainstem

The brainstem, as the name suggests, looks like a stem. It originates at the base of the cerebrum and connects the brain to the spinal cord. It controls basic survival functions such as breathing, heartbeat, regulation of body temperature, and digestion. The brainstem varies in size among vertebrate animal species in relation to the size of the animal. However, its structure remains similar in all cases. This makes good sense when you consider that the brainstem affects processes that are vital to life in all vertebrates.

Cerebellum

The cerebellum is located at the back of the brainstem. It controls sequences of muscle contractions so that movements are smooth and even. Think of a cat's graceful movement or a rabbit's agile maneuvering. Animals, like humans, have well-learned movements. The cerebellum directs these movements.

Since all vertebrate animal species have muscles and can move, all have cerebellums. The size of the cerebellum is dependent upon two factors: the size of the animal and the complexity of its movements.

Cerebrum

The cerebrum is the top part of the brain. It sits above the brainstem and cerebellum and is considered the "thinking" area of the brain. It is the center for thought, memory and emotion, and it controls all voluntary movement. On the surface of the cerebrums of advanced mammals are wrinkles called gyri. The complexity and density of these wrinkles, as well as the relative sizes of our cerebrums, are what truly set us apart from other animals.

Olfactory Bulbs

Obvious olfactory bulbs, or "smell brains," project forward on the cat and rabbit brain replicas. The same structures are present on the human brain, but are relatively smaller in size. The olfactory bulbs receive and process information about odors from sensors in the nose. This information is relayed to several areas of the brain, including the center for smell in the cerebral cortex.

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ACTIVITY 4

CONCEPTS

The size and shape of brain parts vary among mammals.

OVERVIEW

Students compare and contrast life size models and/or drawings of cat and rabbit brains. Students also may make optional plaster models of cat and rabbit brains.

SCIENCE & MATH SKILLS

Measuring, comparing irregular shapes and inferring

TIME

Preparation: 10 minutes; 20 minutes more if making models
Class: 30-45 minutes to make models (optional); 30-45 minutes for discussion

MATERIALS

To make brain models, each student or group will need:

- copy of "Brain Mold Instructions" on page 20
- dental model plaster* (about 1/4 cup per mold)
- BrainLink Molds for cat and rabbit brains*
- water
- disposable cup for mixing
- popsicle stick for stirring

For remainder of activity, each student or group will need:

- plaster cat and rabbit brain models OR purchased plastic BrainLink brain models* (optional)
- copy of "Brain Parts" on page 18
- copy of "Brains from Different Points of View" on page 19 (or use as an overhead)

* See page vi

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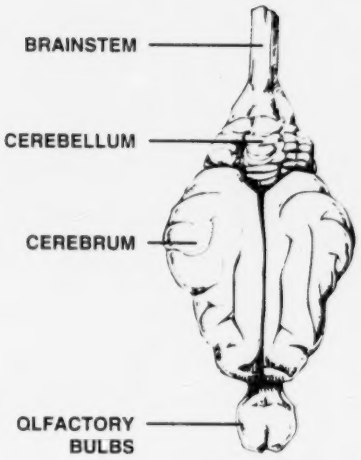
The relatively large olfactory bulbs of the cat and rabbit brains are clear evidence of the importance of smell to the survival of these animals. Similarly, the relatively small olfactory bulbs of the human brain reflect far less dependence of humans on the sense of smell.



CAT (TOP)

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

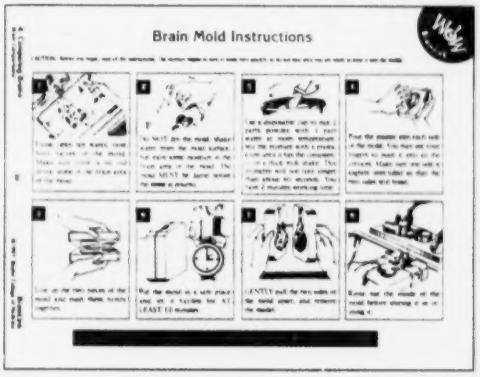
***Skullduggery* chapters:**
The Brain Runs Into a Wall
Sorting Skulls (see science box on page 23)

Explorations:
Can You Match the Animal to Its Brain? (cover)
Gray Matters (page 3)
The Neuro Side (page 7)

Set Up

Students should work in groups of 2-4. This activity will require one class period if you use purchased or previously prepared models of cat and rabbit brains in addition to the student sheets (see page vi for information about BrainLink molds and models) or if you use only the student pages, Brains from Different Points of View and Brain Parts.

An additional class period is necessary if your students will make their own brain models from plaster and BrainLink Molds. To create the models, have students follow the steps on the instruction card, Brain Mold Instructions. The models may be made by students working in cooperative groups or on their own at a center that you have set up in the classroom.



Procedure

1. Let students examine the cat and rabbit brain models and/or the different views of cat and rabbit brains shown on the Brains from Different Points of View student sheet. Ask them to make observations about each one. Consider displaying a human brain model (if available), as well, for comparison. Lead a discussion, asking questions such as:
   - *Can you find the brainstems on the cat and rabbit brains? The cerebrums? The cerebellums?*
   - *Which part connects each brain to the spinal cord?*
   - *Which part of each brain would be located inside the top of the skull?*
   - *What might be a clue to tell the tops of the brains from the bottoms?*

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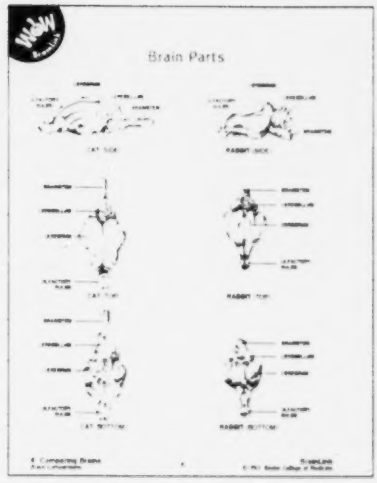
- *How do you think the brains might be situated in each animal's head?*
- *What differences do you notice between the brains?*

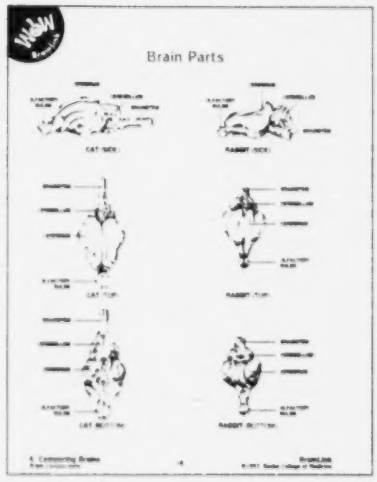
Point out the protruding olfactory bulbs, which are important for animals that depend on the sense of smell.

2. Distribute the activity sheet, Brain Parts, to students. Ask them to use this sheet as a reference to identify the three different brain parts on their models or diagrams. Have the students color the brainstem blue, the cerebellum red and the cerebrum yellow on their sheets. Olfactory bulbs, which connect to the cerebral cortex, may be left uncolored.



3. Using the completed Brain Parts activity sheets, have students color the corresponding parts of the brain replicas or Brains from Different Points of View sheets, using the same colors. (Markers work well for coloring plaster models.)

4. If you have conducted the activity using models of cat and rabbit brains, project an overhead transparency of Brains from Different Points of View. Have students compare the cat and rabbit brains to the sketches from different points of reference. Have the students hold the brains in the same orientations as on the transparency—front, back, bottom, top. This will help the students visualize how the brain sits in the animal's skull. You might ask things like: *If we hold the brain in this direction, where would the eyes be? Where would the ears be? Where would the spinal cord be?*



5. Have students think about how differences in brain structure reflect differences in the activities of cats and rabbits. For example, the cat brain has more gyri than the rabbit brain. In the wild, cats are predators and have to make decisions as they hunt to survive. Rabbits, on the other hand, are plant-eaters and need to make far fewer choices of action than the predatory cat. Have students think about other differences that they can observe. They also should compare the cat and rabbit brains to the human brain.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Can you predict which other animals might have a keen sense of smell? What would you predict about their brains? How could you find out if your predictions are right?
- Do all animals have brains? How about a jellyfish? An earthworm? A frog? Do bacteria or other one-celled organisms have brains? What animal do you wonder about? How could you find the answers?

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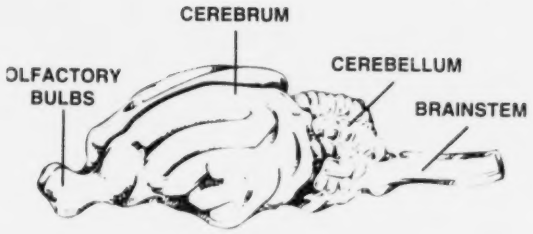
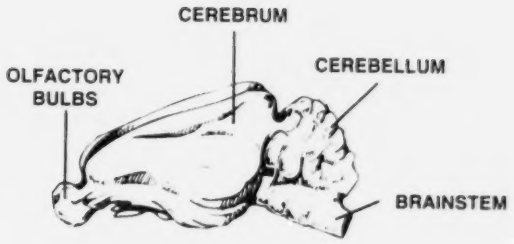
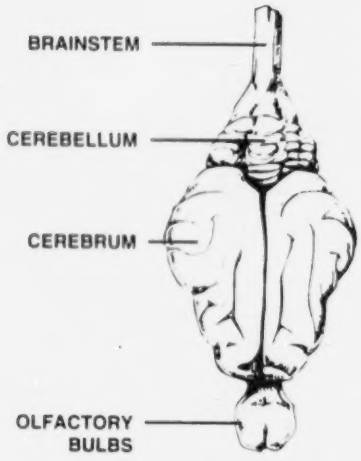
Brain Parts



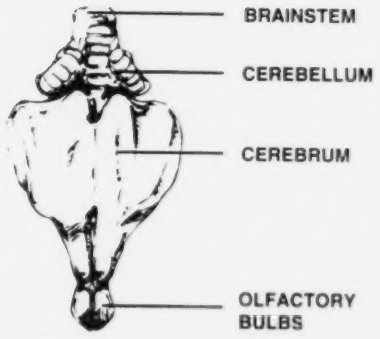
CAT (SIDE)



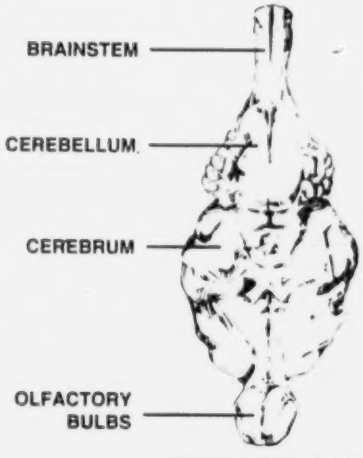
RABBIT (SIDE)



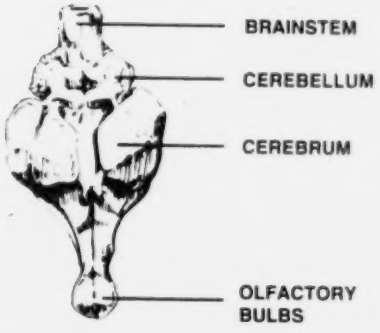
CAT (TOP)



RABBIT (TOP)



CAT (BOTTOM)



RABBIT (BOTTOM)

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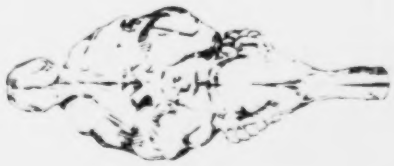
Brains from Different Points of View

BOTTOM



BOTTOM

124

TOP

TOP

SIDE

CAT

SIDE

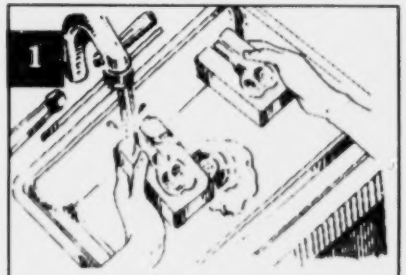
RABBIT

123

Brain Mold Instructions

CAUTION: Before you begin, read all the instructions. The mixture begins to turn to stone very quickly, so do not mix until you are ready to pour it into the molds.

1



Using clean tap water, rinse both halves of the mold. Make sure there is no old dental stone in the brain area of the mold.

2

Do NOT dry the mold. Shake water from the mold surface, but leave some moisture in the brain area of the mold. The mold MUST be damp before the stone is poured.

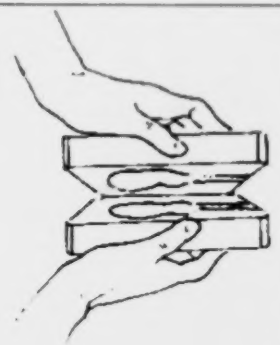
3

Use a disposable cup to mix 2 parts powder with 1 part water at room temperature. Stir the mixture until it has the consistency of a thick milk shake. This probably will not take longer than about 60 seconds. You have 2 minutes working time.

4

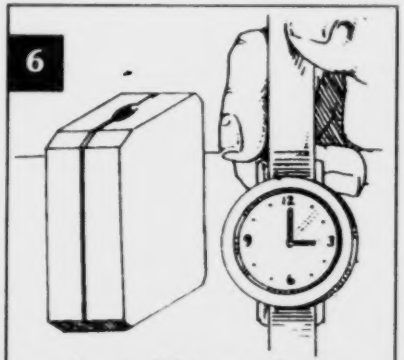
Pour the plaster into each side of the mold. You may use your fingers to push it into all the crevices. Make sure one side is slightly over-filled so that the two sides will bond.

5



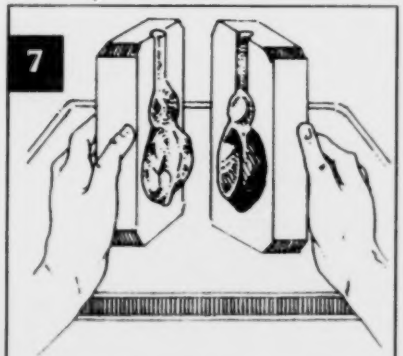
Line up the two pieces of the mold and push them firmly together.

6



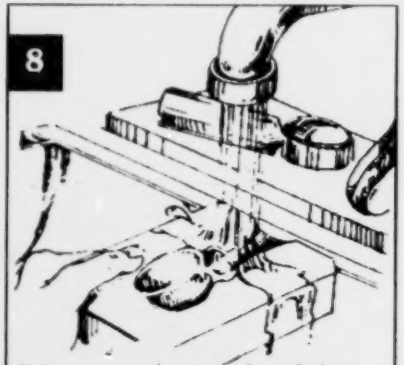
Put the mold in a safe place and let it harden for AT LEAST 10 minutes.

7



GENTLY pull the two sides of the mold apart, and remove the model.

8



Rinse out the inside of the mold before storing it or re-using it.

If sides of mold no longer slip together easily, lubricate with a very light coating of mineral oil.

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How Much Brain Do You Need?

ACTIVITY 5

BRAINLINK BACKGROUND (for the teacher)

Overall, animal intelligence is roughly correlated with the amount of gyri on the cerebrum (see Activity 3: Good Wrinkles). The percentage of brain weight compared to body weight also is a good predictor of intelligence. In fact, the two characteristics usually are related. Usually, mammals with large cerebrums relative to their body sizes also have many gyri.

It is a common error to compare brain size directly with intelligence. Very large animals often have large brains (for example, cow, horse and elephant). Nonetheless, the amount of brain for body weight in these large animals remains small compared to that of other, more intelligent animals (for example, gorilla, chimpanzee, human and porpoise).

Why did some animals evolve to be more intelligent than others? There are many factors that influence how much intelligence an animal needs to survive and reproduce. One way to look at intelligence is to consider how many decisions an animal has to make. Animals that hunt for their food (predators) generally need to make more decisions than animals that do not hunt. Predators that stalk their prey make more decisions than those that simply wait for it to come to them. Animals that are both predator and prey need to make more decisions than animals that are only one or the other. Another important factor is how much an individual animal interacts with and relates to other animals in its group. Some animals live most or all of their lives alone, while others live as part of a larger group that stays together. Animals that live as part of a group are "social" animals, and much of their time is spent interacting with other animals in their groups. For example, predators that hunt together have to coordinate their activities within the group. Any interaction with another animal in the group is likely to involve making decisions, which requires more intelligence.

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

***Skullduggery* chapters:**
Light at the End of the Tunnel
Two Many Professors
(Also see science box on page 23)

Explorations:
Can You Match the Animal to Its Brain? (cover)
Gray Matters (page 2)

CONCEPTS

- Animal intelligence is roughly related to amount of folding of the cerebrum.
- The relative size of an animal's brain as compared to the overall size of its body also is related to intelligence.
- Different species of animals need different attributes to survive in their particular environments.

OVERVIEW

Students are asked to think about and list the activities of several common animals and to estimate how intelligent each animal is by comparing its activities with those of the other animals. Students then compare their estimates with actual brain weight to body weight ratios (provided).

SCIENCE & MATH SKILLS

Collecting background information, inferring, comparing, expressing ratios as percentages, and drawing conclusions

TIME

Preparation: 5 minutes
Class: 45 minutes to list activities and decisions of each animal; 45 minutes to examine brain weight to body weight ratios and draw conclusions

MATERIALS

Each student or group of students will need:

- one copy each of "Predict How Smart" and "Brain Proportions" (pages 24 and 25)

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SET-UP

The activity can be conducted with the whole class or with students working in small groups or as individuals.

PROCEDURE

Looking at Animal Activities (45 minutes)

1. Introduce the lesson with a brief discussion of animal activities based on the ideas in BRAINLINK BACKGROUND. In particular, consider the possible lifestyles of alligators, lions, porpoises, ostriches, wolves, baboons, humans and chimpanzees.

2. Have the students write their ideas about the different animals on the Predict How Smart worksheet. Suggest that students think about whether each animal is predator or prey or both and how this affects its actions. You may want to let them gather additional information about the animals from the library or other resources.

3. Once they have listed types of decisions and activities carried out by each kind of animal, have students rank the animals within each pair according to intelligence, based on the information on their worksheets and their own knowledge of the animals.

4. Finally, have the students rank all eight animals in order of most (1) to least (8) intelligence.

5. Tell the students to set the Predict How Smart sheet aside, so that they can come back to it later.

Looking at Brain to Body Weight Ratios (45 minutes)

1. Provide each student or group of students with a Brain Proportions worksheet. This sheet shows the actual body weights and brain weights of each of the animals listed on the Predict How Smart sheet. The percentage (of the total weight of each animal) that is devoted to the brain has been calculated for students and is shown in the fourth column of the table.

2. Have students compare the percentage of brain tissue composing each animal's weight within each pair of animals. Then have them rank the animals within the pairs according to which has the largest percentage of brain weight to body weight. This should help students understand that some animals have more of their body weight given to brain tissue than other animals.

Alligator: nonstalking predator, hunts alone, may live in groups or alone, little interaction among individuals

Lion: stalking, group-hunting predator, lives mostly in groups (prides), social

Porpoise: both predator and prey, hunts in groups, lives in groups (pods), social, highly interactive

Ostrich: prey, may live in groups when not mated

Wolf: both predator and prey, hunts in groups, lives in groups (packs), social

Baboon: both predator and prey, occasionally hunts, lives in groups (troops), social, highly interactive

Human: both predator and prey, may hunt in groups, social, with very complex interactions among individuals

Chimpanzee: both predator and prey, occasionally hunts, lives in groups (troops), social, highly interactive

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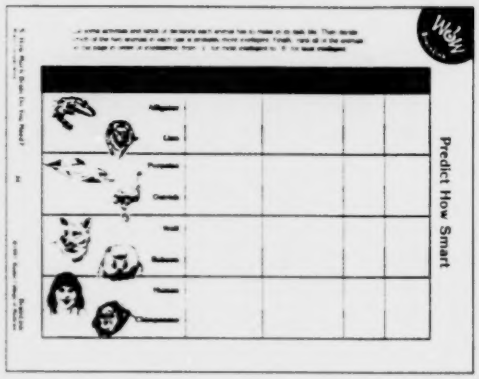
3. Next, ask the students to rank all the animals listed in order of the percentage of brain weight to body weight from the greatest to least (1 = greatest, 8 = least).

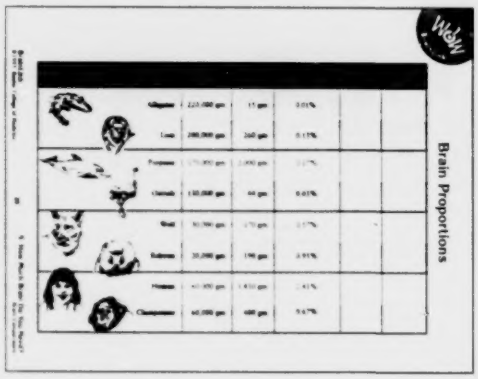
ANSWERS:		
	1 = human	5 = wolf
	2 = porpoise	6 = lion
	3 = baboon	7 = ostrich
	4 = chimpanzee	8 = alligator

4. Ask students to compare the rankings on their Predict How Smart worksheets to the rankings on their Brain Proportions worksheets. They should first compare their rankings within pairs. Does the animal with a greater percentage of brain weight to body weight tend to be more intelligent, based on their predictions?

5. They should then compare their rankings among all eight animals. Is there a rough correlation between percentage of brain weight to body weight and intelligence based on their predictions?

6. Go over the children's results in a large group. Discuss reasons for their answers. Discuss the correlations between percentages of brain weight to body weight and intelligence. Also discuss the discrepancies that may have occurred between students' predictions and the rankings on the Brain Proportions sheet. Ask, *Is there a perfect match between the rankings on your Predict How Smart worksheet and the rankings on your Brain Proportions worksheet? If not, does this bother you? Do you think scientists also have to deal with situations where everything doesn't "match" perfectly?*





BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Do you think there is a limit to how much brain you could use? If our cerebrums were as much as half the total weight of our bodies, do you think we would be smarter? Why?
- Why do you think some individuals of a species are smarter than others? Do you think smarter individuals have more gyri or larger cerebrums than other individuals? If you were a scientist, how would you figure out an answer to this question?
- Which characteristics or behaviors define intelligence in animals? Do you think these ideas also apply to humans?

People who seem to be more intelligent do not necessarily have larger brains or more gyri than others. Instead, differences in abilities to gather, process and apply information are believed to be related to connections within the brain.

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List some activities and kinds of decisions each animal has to make in its daily life. Then decide which of the two animals in each pair is probably more intelligent. Finally, rank all of the animals on the page in order of intelligence, from "1" for most intelligent to "8" for least intelligent.

Animal	Types of Activities	Types of Decisions	Rank Within the Pair	Rank Among all Eight
Alligator				
Lion				
Porpoise				
Ostrich				
Wolf				
Baboon				
Human				
Chimpanzee				

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Predict How Smart

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Brain Proportions

	Animal	Body Weight	Brain Weight	Percentage of Brain Weight to Body Weight	Rank Within the Pair	Rank Among All Eight
	Alligator	220,000 gm	15 gm	0.01%		
	Lion	200,000 gm	260 gm	0.13%		
	Porpoise	170,000 gm	2,000 gm	1.17%		
	Ostrich	130,000 gm	44 gm	0.03%		
	Wolf	30,000 gm	170 gm	0.57%		
	Baboon	20,000 gm	190 gm	0.95%		
	Human	60,000 gm	1,450 gm	2.41%		
	Chimpanzee	60,000 gm	400 gm	0.67%		

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Create a Brain

BRAINLINK BACKGROUND (for the teacher)

At this point in the unit, students should be able to begin to tie together and apply the concepts that have been covered. Some of the basic concepts of this unit are:

- There are three main parts of the brain, and each one has a particular job to do. The brainstem controls basic life functions such as breathing and heart rate. The cerebellum is important for balance and coordination, and for performing well-learned movements. The cerebrum is the largest part of the brain and is larger in more advanced animals. It controls voluntary movements, thinking, and emotions.
- The wrinkles (gyri) in the cerebrum are nature's way of compacting lots of storage capacity (intelligence) into a small space.
- The intelligence of an animal also is related to the proportion of brain weight to body weight. Absolute size of the brain does not determine intelligence.

LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

***Skullduggery* chapters:**
The End of Darkness
A Plan for Mishigara Man (concludes story)
Also review concepts covered throughout in science boxes

***Explorations*:**
Gray Matters (page 2)
Careers for NeuroExplorers (page 7)

SET-UP

Let students work alone or in groups to complete the A Most Amazing Animal activity sheets. This activity can be used to assess the entire unit of study. As long as students' justifications are compatible with the concepts presented in the unit, there are no right or wrong answers.

Consider having students present their creations to the class or letting them display their Most Amazing Animals descriptions and drawings in a central location.

ACTIVITY 6

CONCEPTS

- The brain has three main parts, each with a specific job.
- Wrinkles in the cerebrum allow more tissue to fit into a small space.
- Intelligence in animals is related to the amount of wrinkling of the cerebrum and to the relative size of the brain as compared to body size.

OVERVIEW

Students are asked to imagine characteristics and activities of a fictitious animal and to decide what kind of brain the imagined animal would need to carry out those activities. There are no right or wrong answers, but students should be able to justify their ideas using concepts acquired in Activities 1-5. This activity may be used for assessment.

SCIENCE & MATH SKILLS

Applying prior knowledge to a new situation, calculating percentages and estimating proportions

TIME

Preparation: five minutes
Class: 45 minutes

MATERIALS

Each student will need:

- copy of "A Most Amazing Animal" (pages 28 and 29)

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PROCEDURE

1. Through a class discussion, allow students to review some basic concepts—three brain parts that have different jobs, good wrinkles, brain to body weight significance, etc. Remind students of the differences that they observed among the brains of different animals and how those differences were related to behaviors or activities of the animals.

2. Follow up by challenging students to use their imaginations and knowledge about the brain to create their own animal profiles, using the A Most Amazing Animal activity sheets. You may want to demonstrate the process by profiling an imaginary animal and characteristics with the class as a whole before having them create their own. OR you might provide a real-life example by discussing an animal that they already have considered in this unit, such as the alligator. Point out, for example, that the alligator is a solitary predator, which has a large cerebellum, a long, slender skull, few wrinkles and a brain weight of only 15 grams.

3. When students have completed the activity, have them share their creations with one another. Be certain to assess whether student explanations for characteristics of animals that they have created are compatible with what they have learned.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Are the characteristics of an animal's brain caused by its lifestyle or does its lifestyle determine the characteristics of its brain?

- Imagine an animal even smarter than a human being. Draw what you would predict the brain of that organism would look like.

A Most Amazing Animal

Imagine an animal. What would it be like — graceful or clumsy, fast or slow, smart or not so smart? How would its brain be shaped to fit inside its skull? Create a brain for your animal that matches his or her needs. Have fun!

My animal is a _____

My animal lives in_____

My animal is very good at _____

_____ and _____

My animal is not very good at _____

_____ or _____

This animal weighs about _____

Its brain weighs about _____

That means that its brain is very _____ for its body weight.

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A Most Amazing Animal

Because this animal is so _____, it

probably has a very _____ cerebellum.

Because it is so _____, it probably

has a very _____ cerebrum.

The brain and skull of my animal looks like this:

(draw a side view of the skull showing the three parts of the brain inside)

Its brain looks like that because _____

_____

_____

_____

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Glossary

brain - the control center of the nervous system, located within the skull and attached to the spinal cord; the command center of the body

brainstem or brain stem - structure that connects the rest of the brain to the spinal cord and controls basic survival activities such as breathing, heartbeat, body temperature, and digestion

cerebellum - part of the brain located directly above the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

cerebral cortex - the outermost component of the brain's cerebrum; controls our most advanced abilities, such as speech and reasoning

cerebral hemisphere - either of the two rounded halves of the cerebrum

cerebrospinal fluid - fluid that acts as a protective liquid cushion around the brain and spinal cord

cerebrum - the large, rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement is started

cranium - the bony shell that protects the brain and forms the shape of the head

frontal bone - the front bone of the skull, forming the forehead

gray matter - gray-colored nervous system tissue that forms the outer layer of the cerebrum and is the central component of the spinal cord

gyri - the outward folds or creases on the surface of the cerebral cortex

lobe - a curved or rounded part of a body organ

mammalian - belonging to the group of mammals; warm-blooded vertebrate animals which nourish their young with milk and are characterized by the presence of hair

mandible - jawbone; the only freely movable bone in the skull

maxillary bone - upper bone of the mouth which holds the upper teeth and forms the roof of the mouth

meninges - three thin membranes that cover the brain and spinal cord

nervous system - the brain, spinal cord and network of nerves in the body

neuroscience - a branch of science related to the study of the nervous system

occipital bones - bones that form the back of the skull

olfactory bulb - small, rounded structure that projects forward from the lower part of each cerebral hemisphere, where the sense of smell is processed in the brain

parietal bones - a pair of bones that form the roof of the skull

predator - an animal that captures or seizes other animals for food

prey - an animal hunted or caught for food

sinus - an opening or cavity for the passage of air or fluid within the bones of the skull

skull - all the bones of the head, including the cranium and the facial bones

sphenoid bone - a butterfly-shaped bone on the inside of the skull behind the eyes

sutures - irregular, linear joints where the bones of the skull meet

temporal bones - bones on both sides of the skull next to the forehead and the eyes, in the area of the temples and partly covered by the ears

vertebrate - an animal having a segmented "backbone" or spinal column

zygomatic bone - the cheekbone

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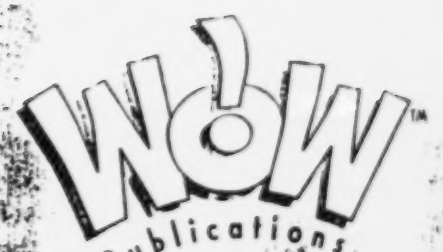

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BrainLink® Adventures
Developed by
Baylor College of Medicine
Houston, Texas
ISBN 1-888997-17-6

THE READING LINK

Reading activities to use with

SKULLDUGGERY

The NeuroExplorers in

A Case of Cranium Confusion

BrainLink® : Brain Comparisons

The Reading Links have been created as ready-to-use reading and writing activities that are directly related to BrainLink adventure stories. They are not intended to represent a comprehensive reading program. The activities are related to reading objectives common to many curricula and cover a range of grade and ability levels. Teachers may wish to select from these activities those that are most appropriate for their own students.

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2000

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Word Meanings

Here are some words from *Skullduggery* that have more than one meaning. Look at the meanings for each word, and then decide which meaning goes with the word in each of the sentences following. Write the number of the correct meaning next to the sentence.

gear
1. clothing
2. equipment for a specific purpose
3. part of a machine that controls force and speed
4. to make ready for effective operation

_____ The Isleys put their bikes in high gear and raced down the road.
_____ The Brain wore his official biking gear.
_____ All the NeuroExplorers were geared up for their adventure.
_____ The NeuroExplorers stowed their hiking gear in their backpacks.

impression
1. a mark made on a surface by pressure
2. an effect, image or feeling that stays in the mind
3. a vague notion, memory or feeling
4. an imitation or caricature of someone in a theatrical presentation

_____ The sight of the two Ottzingers made a vivid impression on my mind.
_____ The skull made an impression in the sand where it had been laying.
_____ At the next meeting, Isley II did a funny impression of his brother fighting off the bats.
_____ Professor Ottzinger had the impression that the NeuroExplorers were both smart and adventurous.

Here are the definitions of some words used in *Skullduggery*. Write a sentence using each word. Your sentences should tell something about the story.

1. **prehistoric** - from the ancient time before people began to record events in writing
2. **sinus** - a space containing air or fluid within the bones of the skull
3. **cranium** - the skeleton of the head except for the jawbone
4. **chasm** - a deep crack or opening in the surface of the earth
5. **monozygotes** - living things derived from a single egg; identical twins
6. **symmetrical** - having an exact matching of parts on both sides of a dividing line

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

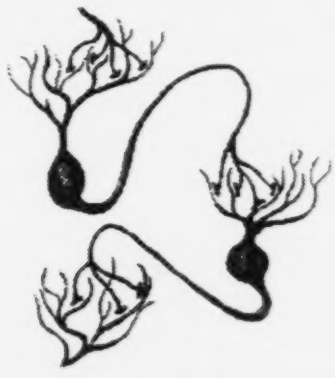
_____

5. _____

_____

6. _____

_____



A *Skullduggery* Crossword Puzzle

ACROSS

4. Skeleton of the head except for the jawbone
7. Animals that attacked the Isleys in the cave
9. Very large cave
10. Part of a plant that is underground
11. Irregular line where two bones of the skull meet
13. Our skulls protect our _____.
15. A negative reply
16. An opening; blank space
17. Trickery; underhanded behavior
19. The professor chose the NeuroExplorers to help him because of their intelligence and _____.
23. They knew the frightening folk-_____ about the Caves at Calicoon.
24. They agreed to meet in the _____ sinus part of the Caves.
25. Professor Ottzinger said to his brother, "Give _____ back, now!"
28. A pronoun I use to refer to myself
29. The skull is made up of 22 different _____.
30. Name of a female NeuroExplorer
32. Do you think that the Mishigara Man might have lived in the Cenozoic _____?
33. The skull had been _____ in the cave.
34. Peter Ottzinger wanted to _____ the skull to the highest bidder.

DOWN

1. The NeuroExplorers Club met _____ Kyle's house.
2. A hollow area in the earth, with an opening to the outside
3. Part of the brain that helps muscles move together smoothly
4. Part of the brain where thinking and decision-making takes place
5. A word used to make things negative
6. Twins are _____-zygotes.
8. The bones of the head
9. A neuron is a nerve _____.
11. A space within the bones of the skull
12. Professor Ottzinger was _____ about his brother's behavior.
14. To express in words
17. The sinuses in the middle of the skull; "Snakes in the _____"
18. Folds on the surface of the cerebrum
20. The NeuroExplorer who wears glasses
21. Intelligence is related to how _____ the brain is, compared to body size.
22. The professor told his brother about a school _____ trip to the Caves.
26. There are two sets of _____ in *Skullduggery*.
27. Professor Ottzinger's first name
28. The Brain's translator
31. They found the skull of a small goat. A baby goat is called a _____.

Details/Supporting Ideas

At the beginning of the book, *Skullduggery*, (pg. iii) there is a section describing each member of the NeuroExplorers Club. Choose three of your own friends or classmates, and write a similar paragraph to describe each of them. Tell about their families, things they like to do, ideas they have, or whatever details you think describe them best.

Look at the picture on page 11 of *Skullduggery*. In your own words, describe this scene as the NeuroExplorers entered the Caves at Calicoon. 1) Tell where and when it took place. 2) Describe as many details as you can. 3) Describe how the characters were feeling at that moment, and why.

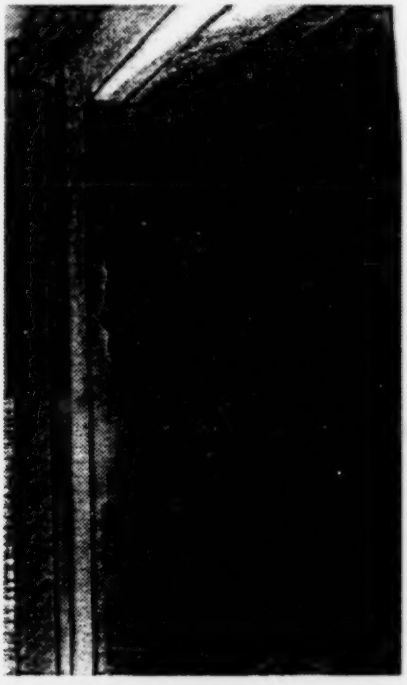
Main Idea

Read the yellow Science Box on page 9. Fill in the circle next to the sentence that best expresses the main idea of that paragraph.

- O The brain is the command center of the body.
- O The brain is made up of billions of cells.
- O The brain controls movements and processes information from the senses.
- O The brain is the most complex organ in the body.

Summary of a Selection

Read the chapter called "Ottzinger's Plan" on pages 5 and 6. In your own words, write a short summary (50 words or less) of that chapter.



Recalling Sequence of Events

Read the chapter called "Snakes in the Sphenoid" on pages 16–19. Find the event listed below that happened **first** in that chapter. Mark **1** next to it. Then number the order (2–5) in which the other events happened.

_____ B.J. fell into the water.
_____ Lakeisha was upset about seeing snakes in the water.
_____ A snake sliced through the gravel toward them.
_____ They spotted a skull in the wall.
_____ They decided the skull was not from a human.

After you have read the whole story, number the order in which the following events took place.

_____ The NeuroExplorers studied the layout of the sinuses in the skull.
_____ Professor Ottzinger came to Kyle's house with a plan that involved the NeuroExplorers.
_____ A false wall was discovered in the Caves at Calicoon.
_____ One Ottzinger was trapped by another.
_____ The skull of the Mishigara Man disappeared from a lab at the university.

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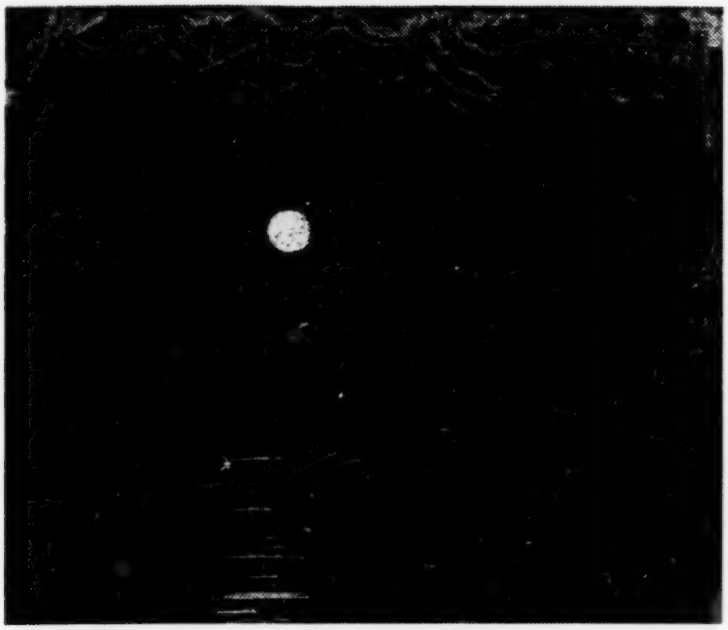


Cause and Effect

What was the effect when Lakeisha found herself in a dark, scary cave, combined with her fear of snakes?

Why did the NeuroExplorers attack The Brain, at the very end of the story? Write a paragraph to explain the cause of their reaction to his new plan.

Point of View/Fact-Opinion

Facts are true. Opinions sometimes are stated as facts, but they might not be true. Decide whether each of these statements related to the story is a fact or an opinion. Write **F** or **O** in each space.

_____ Mountain lions and snakes guarded the entrance to the Caves at Calicoon. (pg. 5)

_____ The NeuroExplorers knew a lot about the brain and the skull. (pg. 6)

_____ The Caves at Calicoon were laid out like the sinuses in a cranium. (pg. 10)

_____ A million billion bats attacked the Isley twins. (pg. 15)

_____ B.J. and Lakeisha fell into water that was full of snakes. (pg. 16–18)

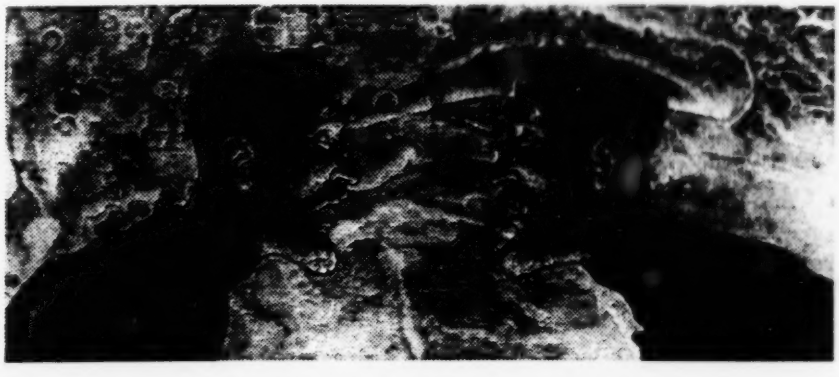
_____ We know that humans are the most intelligent animal because humans' skulls and brains are larger than other animals'. (pg. 24)

_____ "It is more likely that the skull is the Mishigara Man than that you are Professor Ottzinger!" (pg. 27)

Inference/Generalization/Drawing Conclusions

Which of the following generalizations or conclusions can be made from the information given in the story, *Skullduggery*? Fill in the circle next to each statement that you think is correct.

- O The remains of prehistoric men are very valuable.
- O The bones of mammals disintegrate in the earth after a period of about 100 years.
- O The larger the skull, the more intelligent the animal.
- O Professor Ottzinger knew all along that his brother had the missing skull.
- O The NeuroExplorers knew all along that Professor Ottzinger was a twin.
- O The professor and his twin brother are so identical that they think alike.
- O The professor purposely fooled both his brother and the NeuroExplorers in order to achieve his purpose.

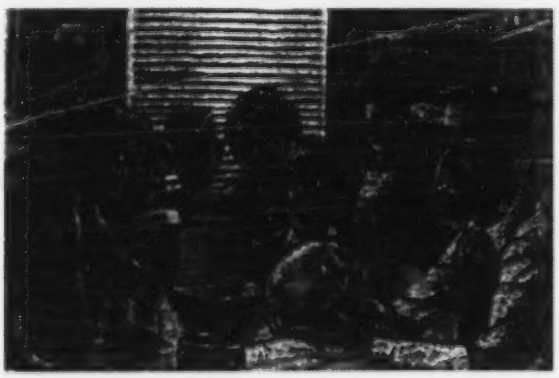


How do you think Professor Ottzinger felt about his twin brother, Peter? Did he understand Peter's actions? Did he love his brother? Did he hate him? Tell what you think, and explain why.

In this story, the members of the NeuroExplorers Club had to decide whether to go on a risky expedition into unknown and frightening territory. Think of all the possible reasons that might have led to their decision to go. Write down as many reasons as you can. Then tell whether or not you agree with their decision, and why.

Predicting Future Outcomes

Think about what might happen after the end of this story. For instance, what happened to Peter Ottzinger? What was the relationship between the two Ottzingers like? Did the NeuroExplorers return to the Caves at Callicoon? Did they see the professor again? Tell what you think might have happened next.



Painting Pictures with Words

Sometimes words are used in an unusual way to "paint" a picture for us. For example, someone might say, "The little girl's cheeks were like roses." Her cheeks were not really like roses, but we get the picture that she had full, pink cheeks.

Look at these word picture sentences from *Skullduggery*. Then see if you can write one of your own. You might describe the darkness or some other feature of the caves, or the action or feelings of a character, or whatever you like.

Sentences from *Skullduggery*

The coolness of the rock walls *wrapped around the NeuroExplorers like a wet blanket.* (pg. 10)

Their flashlights *poked holes through the inky blackness.* (pg. 10)

In another second the cave was again *alive in a blizzard of bats.* (pg. 15)

Suddenly, *like a big black bird of prey raising its wings,* he leaped up, threatening the intruders who unexpectedly came upon him. (pg. 26)

My Word Picture Sentence

_____

_____

_____

My Picture

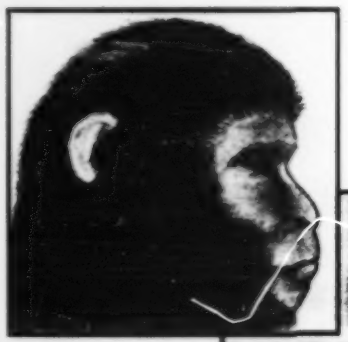
Now draw the picture you have just painted with words.

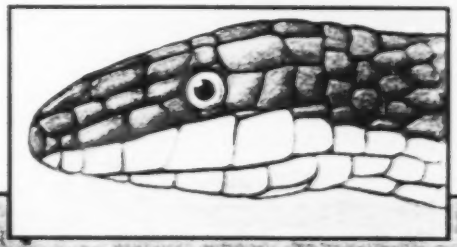
BrainLink
BRAIN COMPARISONS

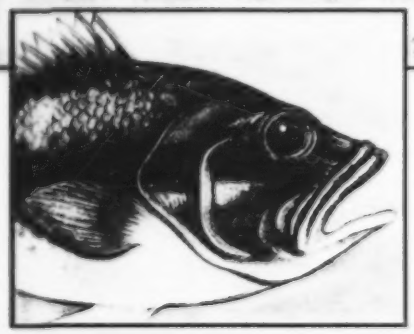
EXPLORATIONS

FOR CHILDREN AND ADULTS

Can you match the animal to its brain?







See page 3 for answers

BRAIN FLASH

In what ways do these brains look alike?
In what ways are they different?

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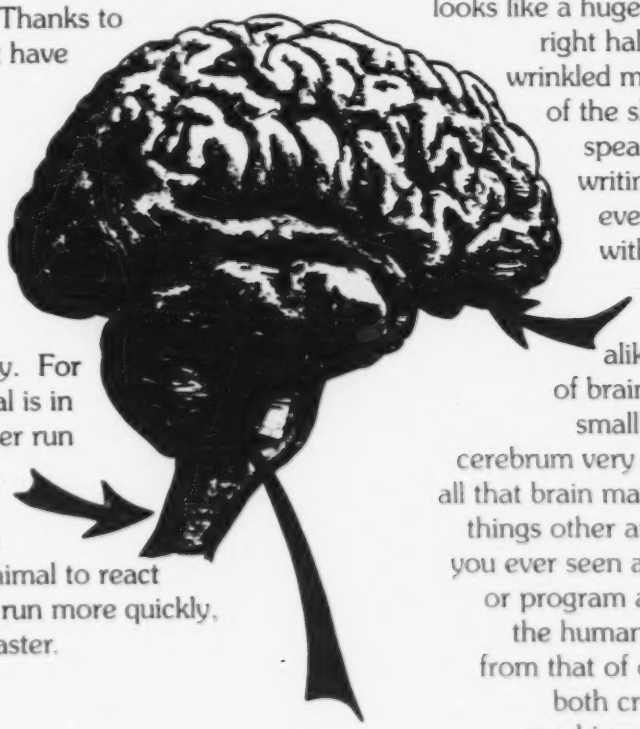
GRAY MATTERS

Some people refer to the brain as "gray matter." If you look at the brain only from the outside, it does look like a blob of grayish pink wrinkles. The brain is the command center of the body. It is enclosed within the skull dome or *cranium* (KRAY-nee-um), the bony shell that protects it. The brain is further protected by a cushion of *fluid* and is covered by thin but tough membranes called the *meninges* (me-NIN-jeez). The brain is the most complex and specialized organ of the body.

One way to think about the structure of the brain is to divide it into three parts: the *cerebrum*, the *cerebellum* and the *brainstem*. Let's start at the brainstem and work our way around:

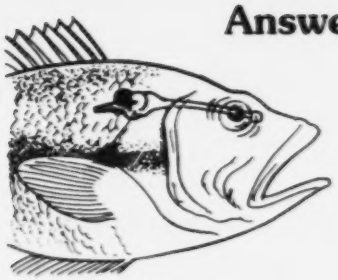
The **brainstem** looks just like its name suggests—a stem. It connects the rest of the brain to the spinal cord. Thanks to our brainstems, we don't have to spend time telling our lungs to breathe, or our hearts to beat, or our stomachs to digest—it's automatic! Brainstems in humans and in animals take away the need to stop and think about *every* body activity. For example, when an animal is in danger it will usually either run away or it will fight. This is called the "fight or flight" response. The brainstem enables the animal to react by telling the muscles to run more quickly, kick harder, or breathe faster.



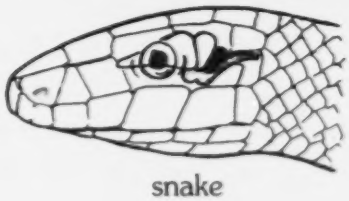
The **cerebrum** (suh-RE-brum) is the largest part of the brain in humans. It looks like a huge shelled walnut with a right half and a left half. This wrinkled mass sits below the top of the skull. It is in charge of speaking, seeing, hearing, writing, remembering, and even dreaming. Animals with backbones normally have cerebrums, but not all cerebrums are alike! Humans have lots of brain matter stuffed into a small skull. This makes our cerebrum very wrinkled. Because of all that brain matter, we can do lots of things other animals can't do. Have you ever seen an animal design a car or program a computer? Because the human cerebrum is different from that of other animals, we can both create and use complex machines in our everyday lives.

The **cerebellum** (ser-uh-BEL-um) looks something like a little cauliflower at the back of the brain and is about the size of a tennis ball in humans. Its main job is to coordinate our muscles so that our movements are smooth and even. Something as simple as picking up a cup is really a complex maneuver. The cerebellum helps our muscles know how much to contract so that we don't crush the cup. Have you ever noticed how babies seem clumsy when they begin to walk? That's because their cerebellums are just beginning to learn how to make their legs work well. Coordinating our walking, reaching, balancing, throwing, and catching are some of the important jobs done by the cerebellum. Animals that hunt need well-developed cerebellums so they can move more quickly and skillfully than their prey. Which animal do you think has a more-developed cerebellum — the hawk or the field mouse?

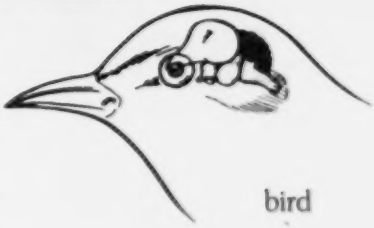
Answers to the cover's Brain Match



fish



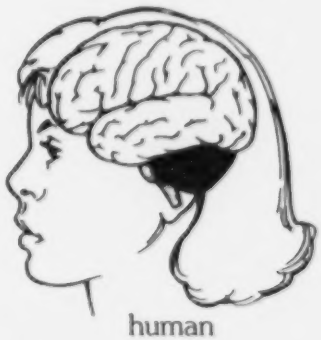
snake



bird

opossum

chimpanzee



human

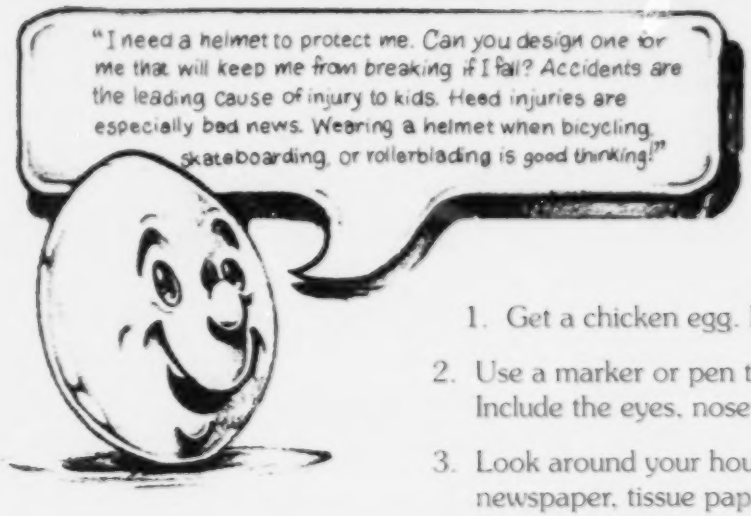
- How many did you guess right?
- After reading "Gray Matters" and examining the answers above, what do you notice about the brainstems? How are they alike?
- What differences are there among the animals' cerebrums? Why might this be?

AMAZING BRAINS

Try this brain matching maze. Can you predict which brain goes with the alligator, the horse and the shark? Find the brain that goes with each animal by tracing the twisted pathways from end to end. When you have matched each one with its brain, turn to the bottom of page 8 to check your matchups.

Did you know that **50 million** Americans are affected each year by diseases or injuries that involve the brain? Perhaps **you** know someone who has had a head injury or a stroke? Maybe you know someone with epilepsy, MS (multiple sclerosis), Alzheimer's disease, or a drug or alcohol problem? Because so many people are affected by diseases or disabilities of the nervous system, Congress passed a public law that made January 1, 1990 the beginning of ten years of attention and research on the brain. The ten years were named ***The Decade of the Brain.*** Research on the brain is part of **neuroscience,** the study of the nervous system.

Use Your Brain – Promote Your Health


"I need a helmet to protect me. Can you design one for me that will keep me from breaking if I fall? Accidents are the leading cause of injury to kids. Head injuries are especially bad news. Wearing a helmet when bicycling, skateboarding, or rollerblading is good thinking!"

Get your family involved and see the different types of helmets each of you can make. Remember, the helmet should keep the egg from cracking when it falls. Here are the directions:

1. Get a chicken egg. Don't boil it.
2. Use a marker or pen to carefully draw a face on your egg. Include the eyes, nose and mouth.
3. Look around your house for helmet material. Try things like newspaper, tissue paper, bubble wrap, styrofoam packing peanuts, plastic or paper cups, play-dough, clay, etc.
4. Make a helmet that lets your egg face see and breathe. Fasten the helmet securely to the egg, but don't cover the eyes or nose.
5. IMPORTANT: Lay several sheets of newspaper on the ground or floor where you are going to test your helmet. In case your egg breaks, newspaper will make it easy to clean up.
6. Now test your helmet. Roll the helmeted egg off of the kitchen counter or table onto the newspaper. It should be **at least** three feet to the floor.
7. Does your egg in its helmet crack when it hits the floor? If so, try again with another egg to design a better helmet. **CONGRATULATIONS to all the helmet "egg-sperts"!**

Cerebral Matter Chatter

I need my brain, my precious brain,
my own cerebral matter.
So when I bike, my helmet's on
as down the street I clatter.
'Cause if I fall, I want to know
my cranium won't shatter;
Or even worse, I'd hate to see
cerebral matter splatter!

Helmets reduce the risk of brain injury by 85%!

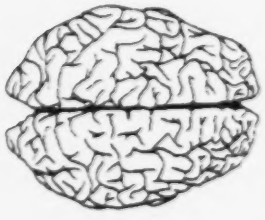
KNEAD A BRAIN

Ingredients

2 cups water
2 cups flour
4 teaspoons cream of tartar
1/4 cup vegetable oil
1 cup salt
red food coloring

Follow this recipe to make a model of the human brain with all its wrinkles and folds. When finished, this recipe should weigh about two pounds. This is about one pound less than the average weight of an adult human brain.

You also can have fun by forming the cerebrum, cerebellum, and brainstem of an animal on the front cover!



Top View

STEP 1: Mix together 2 cups of water, 2 cups of flour, and 4 teaspoons cream of tartar in a large bowl or in a blender. Mix until the lumps disappear.

STEP 2: Add 1/4 cup of vegetable oil to the flour and water mixture.

STEP 3: Put this mixture in a saucepan and add 1 cup of salt. Stir and cook over low heat until the mixture becomes lumpy.

STEP 4: Pour mixture out and let it cool. Then knead the doughy mixture and form into the shape of a brain. Use the drawings of the human brain on the side to make your own model with the three parts – brainstem, cerebellum and cerebrum.

Side View

STEP 5: If you are making a human brain, be sure to form the wrinkles on top. Use a spoon to make the deep wrinkles in the cerebrum. These wrinkles are called gyri (JYE-rye). For realistic blood vessels, you can squirt red food coloring into the wrinkles on top.

This "brain dough" will keep for several months in an air-tight container in the refrigerator.

Lithuanian Brain Scramble

1 pound brains
6 eggs
1/4 cup milk
1 Tbs. butter or margarine
salt, pepper and paprika

1. Soak brains overnight in salted water.
2. Drain, rinse, remove membrane, and chop brain into small pieces.
3. Cook **thoroughly** in butter until brown.
4. Add beaten eggs and milk; continue cooking until eggs become firm.
5. Season with salt, pepper and paprika to taste, and enjoy.

Brains at the Supermarket

Visit your local supermarket or meat market to view, and possibly purchase, a brain. Why? In many cultures, brains are eaten as a delicacy. Meat departments often have them packaged like any other meat, and you can see what a real animal brain looks like. Ask the butcher to show you a brain out of the package. Most brains sold in supermarkets weigh between 2 and 2.5 pounds and come from cows or pigs. Check it out! If you have never eaten brain before and you are feeling adventurous, try a recipe from a foreign land.

Mexican Sesos

1 pound brains
2 cloves garlic, minced
1 Tbs. butter or margarine
2-3 Tbs. cornstarch
1 Tsp. salt
black pepper, cumin and Tabasco
tortilla chips or soft tortillas

1. Soak brains overnight in salted water.
2. Drain, rinse, remove membrane, and cut the brain into small cubes.
3. Cook **thoroughly** in butter with garlic until brown.
4. Stir cornstarch into 2 cups cold water.
5. Add to the browned brains and cook to thicken, stirring constantly.
6. Season to taste with salt, pepper, cumin and Tabasco.
7. Serve as a dip for tortilla chips or wrapped in a soft tortilla.

BRAIN FLASH

The human brain contains about 100 billion individual nerve cells (neurons). This is comparable to the number of stars in the Milky Way.

BRAIN FLASH

Did you know that tribes in New Guinea used to prepare and eat the body parts of deceased family members? The brain was reserved as a special gift for women in the family. Unfortunately, it often was a deadly gift!

The women got a disease of the central nervous system called ***kuru*** (KOO-roo), or "shaking disease," which caused their death.

The average adult *human* brain weighs about 3 pounds or 1400 grams. About how heavy is that? What can you find in your grocery store or at home that weighs about three pounds? Guess three things and weigh them to see if you were right. When you find one, hold it and think about the fact that a human brain is just about that heavy. Is the object you found about the same size as a brain? If not, what can you find that is more like the brain in size, even though it may be heavier or lighter? Have you found anything that you think is like a human brain in *both* size and weight?

THE FAR SIDE By GARY LARSON

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"Well, time for our weekly brain-stem-storming session."

THE NEURO SIDE

Did you ever hear someone say, "Let's brainstorm," meaning to think of a new way of doing something or solving a problem?

Some people believe that the dinosaur, a type of reptile, didn't have a very well-developed brain—possibly not even a cerebrum!

Gary Larson likes to capture the humor in science. This episode of ***The Far Side*** highlights this idea by calling this dinosaur meeting a "brain-STEM-storming session."

What about you? Can you create your own cartoon based on something you learned from this issue of *Explorations in Neuroscience*?

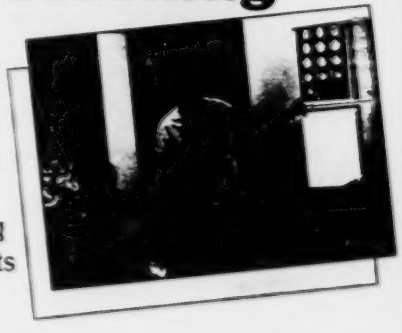
Careers for Neuro-Explorers: Teaching

Did you ever wonder about something you've seen or heard and ask *why*? Asking why is important to being a good student and a good scientist. Let's meet a modern neuro-explorer who is a TEACHER and helps others to find the answers.

Neuro-Explorer: Robert Thalmann, Ph.D.
Associate Professor of Cell Biology
Baylor College of Medicine
Houston, Texas

Dr. Thalmann, what do you do?

I teach medical school students, who are learning to be doctors, about the brain and how it works. All future doctors need to know about the brain and the nervous system. I also do research on a part of the brain called the hippocampus (hip-o-KAM-pus). I try to find out how different cells in the hippocampus communicate with each other.



What do you find the most fun or most interesting about your work?

Teaching is exciting because my students really become interested in the nervous system when we do experiments in the lab. Once I've got their interest, they want to learn what they can from books. As a teacher, I can pass on my love of science to others.

What advice do you have for future scientists?

Science is the very best job for a curious person. You get to ask questions and then figure out the answers. So, when you get interested in something, try to find out more about it. Go to the library, ask others who know more than you do, and remember to use your own eyes, ears, and brain.

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Your Colossal Cranium

Your brain is made of soft tissue, which can be bruised or torn. The skull serves as a protective case to keep the brain from being easily damaged. Imagine how an egg yolk floats inside an eggshell. The brain also is floating in fluid called the **cerebrospinal** (suh-ree-bro-SPI-nal) **fluid.** The **cranium** is the domed part of the skull that covers the brain. You also have facial bones which provide a frame for your eyes, nose and mouth. The front portion of the skull is a honeycomb of bone and air spaces **(sinuses)** that act like an "air bag" for the brain and help absorb the force of a blow.

Did you know that when you were born your cranium was not solid? Babies have "soft spots," or **fontanelles** (fon-tuh-NELZ), on the top of their heads where the bone has not **ossified** (OS-uh-fide), or turned hard. Usually by the time you are about two years old, the last of the soft spots has been filled in.

The places where the soft spots grow together form jagged lines called **sutures** (SOO-churz). They fit together like the pieces of a jigsaw puzzle. The sutures do not begin to fuse solidly together until you are around 25 years old. This allows the skull room to expand as the brain slowly grows to maturity. After age 25, the sutures gradually turn to solid bone. Then you might say that a person can truly be called a "bonehead"!

Animals have craniums for the same reason as humans – to protect their brains! In the puzzle at the right, try to guess which animal's bones are pictured. To find the answer, connect the dots.

BEST COPY AVAILABLE

BRAIN FLASH

Did you know that the human brain is about the consistency of things like warm oatmeal, or custard, or butter at room temperature? This important organ is very delicate and needs protection.

Answers to Amazing Brains from page 3

a. Alligator
b. Horse
c. Shark

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